IN TWO SECTIONS—SECTION ONE



# MECHANICAL ENGINEERING

## INCLUDING THE ENGINEERING INDEX

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### IN THIS NUMBER



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TABLE OF CONTENTS



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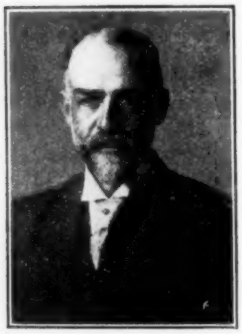
# Contributors and Contributions

### Surge-Chamber Problem

W. F. Durand, professor of mechanical engineering at Leland Stanford Junior University since 1904, has utilized the law of kinematic similitude in developing a laboratory method of solving the hydraulic surge-chamber problem. His paper on the subject, which forms the leading article in this issue, describes his model method and compares its advantages with those of analytical methods. Professor Durand was graduated from the U. S. Naval Academy in 1880 and remained in naval service for seven years. He was professor of mechanical engineering in the State Agricultural College of Michigan for four years and of marine engineering in the School of Marine Engineering and Naval Architecture in Sibley College, Cornell University for twelve years. Professor Durand has been active in the fields of marine construction and steam and hydraulic power-plant engineering. He served as chairman of the National Advisory Committee for Aeronautics and later as scientific attaché to the American Ambassador to France.



W. F. Durand

### Oil-Injection Type of Internal-Combustion Engine

In his article in this issue, Dr. C. E. Lucke discusses the importance of the liquid-fuel development in the combustion-engine field and the various difficulties encountered in adapting the gas-burning engine to light and heavy gasolines. The problem of a shortage of these fuels, which is becoming a serious one owing to the heavy demands of the motor-car and allied means of transportation, makes imperative the development of an engine which will burn any kind of liquid fuel. Dr. Lucke has done important work as laboratory director and head of the department of mechanical engineering at Columbia University, organizing new courses and methods of instruction. He has also practiced consulting engineering and made both commercial and scientific investigations along various lines.

### The Hydraulic Relay

The increasing need for some form of supplemental power to fully utilize certain eastern water powers makes Mr. E. B. Powell's paper, in this issue, of timely value to all those interested in power-station developments. After engineering training with various New York firms, Mr. Powell, was for three years in charge of the mechanical-testing laboratory of the New York Edison Company. Since 1907 he has been with Stone & Webster Engineering Corporation as mechanical engineer in charge of betterment of operation of power plants.

### Steam Superheaters

Recognition of the advantages of superheated steam has been gradually increasing during recent years, until today there are few designers of large steam plants who do not make use of superheat. With the adoption of steam of 800 deg. fahr. temperature for general use, which many engineers hold possible, high fuel economies will be obtainable not only in locomotives, marine service, railway power plants, but especially in stationary power plants. This issue contains an article by H. B. Oatley in which is traced the development of the use of superheated steam, including the design, application and use of steam superheaters. Mr. Oatley has been active in the development of the superheater for some years and has been associated with the Locomotive Superheater Company of New York since 1911.

### Condensing Apparatus

The article in this issue by Messrs. Stivers and Brewer describes experiments conducted by them to determine the relative efficiency of various types of condensers used in the distillation of liquids. Both authors are connected with the Port Arthur refinery of The Texas Company. Following his graduation from Georgia School of Technology and post-graduate work at Cornell University Mr. Stivers spent several years in the creosote-oil business. Mr. Brewer was graduated from the Massachusetts Institute of Technology and was for three years assistant valuation engineer with the Public Utility Commission of the State of New Jersey.

### Rolling Sheet Steel

The problem of rolling thin steel sheets is one which should be approached from the scientific experimental side, according to S. B. Ely, whose paper on this subject appears in this issue. Mr. Ely was a draftsman for four years after his graduation from the Massachusetts Institute of Technology. He then engaged in sheet-steel work with various firms. He is now assistant professor of commercial engineering at the Carnegie Institute of Technology.

### Corrosion in Iron and Steel Pipes

In a paper presented before the Ontario Section of the A.S.M.E. at Toronto February 2, 1921, and given in slightly abridged form in this issue, F. N. Speller of Pittsburgh, Pa., metallurgical engineer for the National Tube Company, outlined the general causes of corrosion of iron and steel and discussed means of protection against exterior and interior corrosion of iron and steel pipes. Mr. Speller has been connected with the National Tube Company since 1901, during which time he has developed a process for removing scale from pipes. He has also designed and put into operation a plant for control of corrosion in hot-water pipes and boilers. He has been engaged in research work on the cause and prevention of corrosion since 1907.

### The New 16-in. Disappearing Carriage

Major G. M. Barnes, chief of the Railway and Seacoast Carriage Section, of the Ordnance Department U. S. A., describes in this issue of Mechanical Engineering the new 16-in. disappearing carriage for harbor defence. He deals with the subject from an engineering viewpoint in the hope that the solution of some of the problems encountered in its development may be applicable to other engineering problems. Major Barnes was graduated from the University of Michigan in 1910 and since that time has served in the Coast Artillery and Ordnance Department, for the last five years in charge of the design of railway and seacoast artillery for the United States.

# MECHANICAL ENGINEERING

Volume 43 | October, 1921 | Number 10

# Application of the Law of Kinematic Similitude to the Surge-Chamber Problem

By W. F. DURAND,[1] STANFORD UNIVERSITY, CAL.

*The problem of the hydraulic surge chamber gives rise to certain differential equations which do not admit of solution in analytical form. Under these conditions, various modes of treatment have been proposed. The present paper develops and describes a comprehensive experimental method utilizing the law of kinematic similitude. By this method a laboratory model of convenient dimensions is set up and subjected to a program of operation corresponding to that for the field installation. The movements of water level, times, etc., as measured for the model, are then multiplied by suitable relation factors, thus giving the results to be anticipated for the field installation.*

*The model may thus, in a sense, be considered as a form of mechanism which solves the equations as applied to the model form, and these results multiplied by suitable relation factors give the corresponding results to be anticipated in the field case.*

*The principle advantages of the model method are as follows:*

*1 The model is simple and readily set up. Once in operation, the most varied conditions may be quickly examined, thus making possible a range of examination in detail, the extent of which would be quite impracticable by any methods of numerical computation.*

*2 In all analytical methods of treatment, pipe-line friction has been assumed to vary with the square of the velocity. In the model method the friction may be taken to vary with $v^n$, where n is usually found to be about 1.85.*

*3 In analytical methods the surge chamber is usually taken as uniform in cross-section. With the model, the chamber may be of any form whatever.*

*4 The model method is readily extended to the case of a surge chamber with spillway or to the case of multiple chambers on one pipe line.*

*5 The model method provides readily for the examination of periodic fluctuations in power demand, of any amplitude and any periodicity. The examination of such fluctuating programs is beyond practical reach by numerical methods.*

It is assumed in what follows that the general physical phenomena of surges and of surge-chamber operation are familiar to the reader. They have been often described both in textbooks on hydraulics and in special papers on the subject, and to such sources the interested reader may refer for more complete details.[2]

The problem of the surge chamber as a problem on hydraulics gives rise to a pair of simultaneous differential equations as follows:

$$\frac{L}{g}\frac{dv}{dt} = H - y - cv^n \qquad [1]$$

$$\frac{F}{A}\frac{dy}{dt} = v_2 - v \qquad [2]$$

where $L$ = length of conduit

$v$ = velocity

$H$ = head measured from datum at bottom of chamber to level of water in supply reservoir

$y$ = height of water level in surge chamber above datum at bottom of chamber

$F$ = cross-section area of surge chamber

$A$ = cross-section area of conduit

$c$ = factor such that $cv^n$ = sum of friction and velocity heads at velocity $v$

$n$ = index in expression $cv^n$ and usually found numerically to be about 1.85.

Regarding the factor $c$ in Equation [1] it may be noted that the sum of the velocity and friction heads would usually be represented as the sum of two terms of the form $v^2/2g + bv^m$, where $m$ is the index of variation for frictional resistance with velocity and $b$ is the factor connecting $v^m$ with loss of head due to friction and depending, primarily, on length of line, mean hydraulic radius, and character of surface. It is, however, simpler to combine these two terms into one (the first is in all practical cases relatively small), and it is quite as easy to represent the sum, as derived experimentally, by a single term of the form $cv^n$ as it is for the friction head alone by a term of the form $bv^m$. In any actual case, furthermore, the values of $m$ and $n$ would be hardly distinguishable. The value of $n$ thus indicated is usually found to be about 1.83 or 1.85. For very rough surfaces it will approach more nearly to 2.

It should be further noted that the actual details of the transition phenomena during the period of change of load and while settling down to new conditions will depend on the character of the governor action during the same period. At least four assumptions may be made regarding the results of such action, as follows:

(a) A uniform rate of flow at the amount required for the new power demand under steady flow conditions

(b) Constant power output from the wheel

(c) Constant power input to the wheel

(d) Control valve or gates put immediately into the position corresponding to the final steady flow condition and left unchanged during the transition period.

No one of these assumptions is accurate. If we could assume the load demand to instantaneously change and then remain uniform at the new value and if we could assume the governor capable of exercising perfect and complete control, then it would, under the new conditions, maintain constant speed and hence constant power.

No governor is, however, able to operate in this ideal manner, and the load changes are not usually instantaneous followed by uniformity at the new value. Actually the load may change suddenly, followed by minor variations in settling to something approaching a uniform value. The governor is, furthermore, chasing back and forth with a time lag between speed changes and the actual operation of gate or valve mechanism. Any attempt to include governor action in the equations for the movement of the water in the surge chamber can thus be only partial at the best, and such attempt greatly complicates the resulting equations and their treatment, no matter by what method.

Equations [1] and [2] are based on assumption (a), that of a constant-volume flow at the rate which, under steady conditions, would serve to give the power required under the assigned new conditions of power demand, and this assumption results in such a notable simplification in the analytical expressions involved that mathematical discussion of the problem is usually based on the equations in this form.

It does not follow, however, that for the application of the law of similitude this particular assumption is the one best suited to the experimental phase of the problem. As will be shown at a later point, assumption (d) is by far the most convenient for experimental realization. However, the determination of the conditions for similitude and of the numerical ratios through which the various relations are expressed is quite independent of the

[1] Professor of Mechanical Engineering, Leland Stanford Junior University. Mem. Am.Soc.M.E.

[2] Trans. Am.Soc.M.E., vol. 34 (1912), p. 319; *Western Engineering*, December 1913.

Presented at the 1921 Spring Meeting of the National Academy of Sciences, Washington, D. C., but published only in brief abstract in the Proceedings.

particular assumption which may be made regarding the results of governor action on the flow conditions during the period of change. Hence, since assumption (a) leads to the simplest system of Equations [1] and [2], we may conveniently use these equations for the further development of the general problem, and then at a suitable point return to the question of the consequences to be anticipated from these various assumptions regarding the results of governor action during the period of change.

As treated in the literature of the subject, furthermore, the index $n$ is usually taken as 2. This corresponds in effect to the assumption that friction loss varies as the square of the velocity—an assumption which is well known to be definitely in error. The difficulties of analytical treatment in any form are, however, so vastly increased by the assumption of a value of $n$ such as 1.85, that the value 2 has been commonly accepted for the index of $v$.

The two equations with the value $n = 2$, when combined, give rise to a differential equation of the second order and second degree and containing both the first and second powers of $dy/dt$. This equation does not seem to admit of analytical solution, at least in terms of present known functions.

Some years ago the author made brief mention of the possibility of treatment by experimental methods making use of the principles of kinematic similitude,[1] and at a subsequent time[2] a discussion

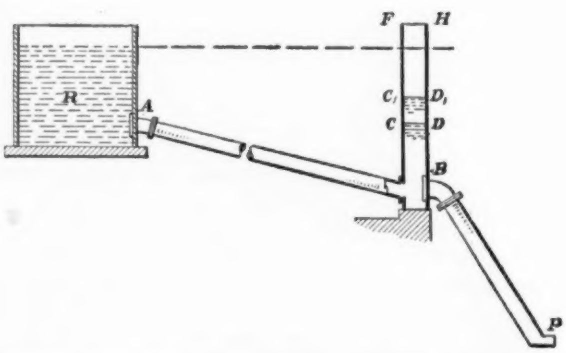



FIG. 1 DIAGRAMMATIC REPRESENTATION OF RESERVOIR, CONDUIT AND SURGE CHAMBER

of the problem was published covering the application of this method to the case with the index $n = 2$.

The present paper aims to generalize this mode of treatment by extension to the case with a general index $n$, and including likewise the possible case of two or more surge chambers connected to the same line.

It will be evident that if the equations with $n = 2$ do not admit of analytical solution, any such mode of treatment with $n = 1.85$ will be likewise and still more definitely out of the question, and if any general mode of treatment is to be found, it will needs fall under one or the other of two classes: (1) numerical, by the method of numerical quadratures, so-called; or (2) experimental, by the use of a model connected with the actual field case through the principles of kinematic similitude.[2] It is with the latter of these that the present paper deals.

## KINEMATIC SIMILITUDE

Before attempting to develop the conditions of kinematic similitude between two cases, it is necessary first to note what is implied by this term.

To develop the idea, let Fig. 1 denote diagrammatically the characteristic elements of a given case. $R$ denotes the reservoir supplying water through the conduit $AB$ to a power plant at $P$. Let $BFH$ denote a standpipe or surge chamber relatively near to $P$. Let the plant be running at a steady rate of output with a velocity of flow $v_1$ in $AB$. Then, taking the case of demanded load, let there come a sudden demand for more power and consequently more water such as would require, under steady conditions in $AB$, a velocity $v_2$. The conditions of flow in $AB$ will, however, not permit of an immediate response. The proximity of the surge chamber to the power house does, on the other hand, permit of prompt or sensibly immediate response and accordingly the additional amount of water required to make up the supply to the wheel, corresponding to a velocity $v_2$ in $AB$, is drawn from $BFH$. In consequence the level in $BFH$ falls, occupying at a given instant of time immediately after the new power demand, some level such as $CD$, while the level for steady-flow conditions still remains sensibly at $C_1D_1$. This difference of level, the actual level lying below that for steady conditions, means the development of an accelerating head measured by the difference between these two levels. In response to this accelerating head, the velocity of flow in $AB$ will begin to increase and such increase will continue so long as the accelerating head remains operative—that is, so long as the actual level lies below that for steady-motion conditions. In consequence the velocity $v$ will pass gradually through a series of values on the way from $v_1$, the initial value, to $v_2$, the final value. In general, during this period the actual level will lie below the level for steady conditions with the actual velocity $v$, thus constituting a continuing accelerating head and in answer to which the water in $AB$ undergoes a corresponding positive acceleration. If the conditions should be such as to bring about a gradual decrease of this accelerating head as the velocity approaches the value $v_2$, ultimately vanishing when $v = v_2$, then the series of transition phenomena comes to an end with this condition, and the water level remains at its new location with velocity $v_2$. Actually, however, these conditions are not fulfilled. When the velocity first reaches $v_2$ the acceleration head is still positive; that is, the actual level is below that for steady conditions with velocity $v_2$, and in consequence the velocity is carried on to some value greater than $v_2$ until finally the two levels do come together, but with a velocity $v > v_2$. This means more water is coming along $AB$ than is required at the power plant, and in consequence the excess will be received by the surge chamber and the actual level of the water will rise above its location for steady-flow conditions, thus producing a *retarding* head and gradually reducing the velocity $v$ from its maximum value back toward $v_2$ again. On reaching $v_2$, however, the actual level will still lie above that for steady-flow conditions, a corresponding retarding head will still be operative and the velocity will be carried beyond and below $v_2$ until the retarding head vanishes and becomes replaced by an accelerating head, when the velocity is again carried upward toward the value $v_2$. In this way there will be an indefinite number of oscillations of level about the final location and a corresponding indefinite series of oscillations of value of the accelerating head from positive to negative and back again, and a corresponding series of fluctuations of velocity above and below $v_2$—all of these oscillations and fluctuations of continuously diminishing amplitude, until finally they all sensibly die out together with the velocity at $v_2$ and the water level at the corresponding location for steady conditions.

In the case of rejected load and a sudden excess of water flowing in $AB$, with $v_2$ less than $v_1$ the excess water will be received by the surge chamber and will result in a rise in the actual level above that for steady-flow conditions, thus producing a retarding head. In answer to this, the velocity will become gradually *reduced* from $v_1$ toward $v_2$, passing through a series of fluctuations, with corresponding oscillations in the water level, in manner entirely similar to that for demanded load.

It will then be evident that if we should represent graphically on a time axis the essential phenomena which characterize this transition period, we should have curves as follows:

1 A time history of the movement of the actual water level $CD$

2 A time history of the movement of the level for steady conditions with the actual velocity $v$

3 A time history of the difference of these two levels, constituting in general (for demanded load) an accelerating head, and measured by the left-hand member of Equation [1]

4 A time history of the velocity $v$ as it passes through periodic fluctuations from the initial value $v_1$ to the ultimate value $v_2$.

Suppose such a group of curves for the first part of the transition period be as represented in Fig. 2. Let us designate the physical system to which these curves correspond as system $A$. Now let us imagine a system $B$, comprising the same elements, but different

[1] Trans. Am.Soc.M.E., vol. 34 (1912), p. 319.

[2] *Western Engineering*, December 1913.

in size and proportion, and so related to $A$ as to fulfill the following conditions:

For any time $t$ on system $A$ there will be a corresponding value of any one of the four characteristics above noted. Then for system $B$, let there be a time $\alpha t$ for which the value of the same characteristic will be related to the value for system $A$ by a ratio $\beta$ and where $\alpha$ and $\beta$ are constant factors. This would mean that if curves for system $B$ were run out similar to those for system $A$, then the two sets of curves would be geometrically similar, being related along the axis of abscissæ by the ratio $\alpha$ and along the axis of ordinates by the ratio $\beta$. It would mean, furthermore, that if the two sets of curves were plotted with suitable scale units, related for $t$ in the relation of 1 to $\alpha$ and for any one of the four characteristics in the relation of 1 to the corresponding $\beta$, the two curves would become coincident. It will, of course, be understood that there will be one value of $\alpha$ for the time relation and two

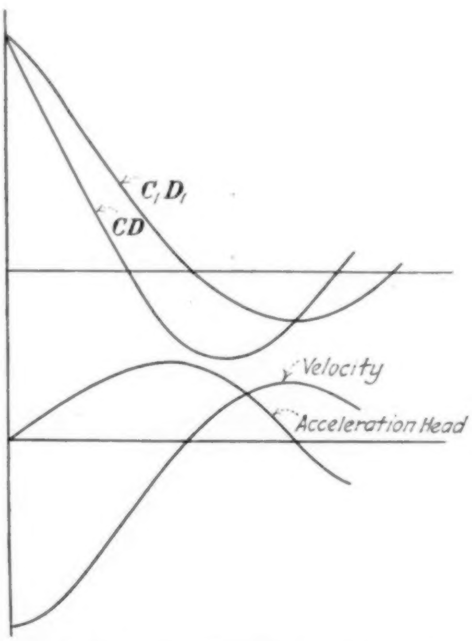



FIG. 2 CURVES REPRESENTING ESSENTIAL PHENOMENA CHARACTERIZING FIRST PART OF TRANSITION PERIOD

values of $\beta$, one for the three vertical dimensions or movements and one for the velocity $v$.

Now two systems $A$ and $B$ fulfilling the conditions thus indicated are said to have kinematic similitude.

It is then clear, if $B$, let us say, is a field case and $A$ is of laboratory dimensions and if we can determine the coefficients $\alpha$ and $\beta$, that experimental observation on $A$ will serve to determine through $\alpha$ and $\beta$ the results to be anticipated for $B$.

We must next inquire as to the conditions for realizing such relation of kinematic similitude. Let us first assume that it *is* realized and by way of notation let:

$p$ = ratio of conduit lengths = $L$ ratio
$q$ = ratio of the two values of $c$ = $c$ ratio
$r$ = ratio of velocities = $v$ ratio
$s$ = ratio of the times = $t$ ratio

Now referring to Equation [1], it has been stated (without present proof) that the expression $(L/g)(dv/dt)$ is the measure of an accelerating head; that is, the measure of the head required to produce the acceleration $dv/dt$. This head is, of course, a vertical dimension. Now since Equation [1] is a physical equation, it must be homogeneous in all its terms. That is, all terms must represent vertical dimensions. In fact, it is readily seen that the right-hand side of the equation is composed of members, each one of which is a vertical dimension, and the algebraic combination of which is a measure of the difference between two water levels such as $CD$ and $C_1D_1$, Fig. 1, and which (as previously stated) constitutes the accelerating head.

Now suppose two such equations, one relating to system $A$ and one to system $B$. Then if the conditions of similitude are fulfilled, there will subsist between the numerical values of the corresponding terms of these two equations, a constant ratio—that corresponding to vertical dimensions or vertical movements. This means specifically that the terms $(L/g)(dv/dt)$, $H$, $y$, $cv^n$, all represent vertical distances or movements, and that between them all, for systems $A$ and $B$, there subsists the one constant ratio. If, therefore, we can determine this ratio for one, we have it for all. But with the notation assumed above, we have immediately:

$$v^n \text{ ratio} = r^n$$
$$cv^n \text{ ratio} = qr^n$$

Hence we shall have for all vertical dimensions or movements the ratio $qr^n$. We may denote this in general as the $y$ ratio and have, therefore:

$$y \text{ ratio} = qr^n$$

Then since, in Equation [1], this ratio $qr^n$ applies to each term individually, it must apply to the first term. Hence we may write:

$$\frac{L}{g}\frac{dv}{dt} \text{ ratio} = qr^n$$

But the $L$ ratio $= p$, the $dv$ ratio must equal the $v$ ratio which is $r$, and the $dt$ ratio must equal the time ratio which is $s$. Hence we have:

$$\frac{pr}{s} = qr^n$$

or

$$s = \frac{pr}{qr^n} = \frac{pr}{y \text{ ratio}} = \frac{p}{qr^{n-1}}$$

Again, in Equation [2], if the conditions of similitude are fulfilled, the ratio $r$ will apply to each term individually. It must therefore apply to the first term and we may write:

$$\frac{F}{A}\frac{dy}{dt} \text{ ratio} = r$$

But the $dy$ ratio must equal the $y$ ratio and the $dt$ ratio the $t$ ratio. Hence we have:

$$\left(\frac{F}{A} \text{ ratio}\right)\left(\frac{qr^n}{s}\right) = r$$

or

$$\frac{F}{A} \text{ ratio} = \frac{rs}{y \text{ ratio}} = \frac{pr^2}{(y \text{ ratio})^2} = \frac{p}{q^2r^{2n-2}}$$

Now collecting these various ratios we have as follows:

$$L \text{ ratio} = p \quad \ldots\ldots [3]$$
$$c \text{ ratio} = q \quad \ldots\ldots [4]$$
$$v \text{ ratio} = r \quad \ldots\ldots [5]$$
$$H, y \text{ ratio} = qr^n \quad \ldots\ldots [6]$$
$$t \text{ ratio} = s = \frac{pr}{y \text{ ratio}} = \frac{p}{qr^{n-1}} \quad \ldots\ldots [7]$$
$$\frac{F}{A} \text{ ratio} = \frac{rs}{y \text{ ratio}} = \frac{pr^2}{(y \text{ ratio})^2} = \frac{p}{q^2r^{2n-2}} \quad \ldots\ldots [8]$$

and to which we may add:

$$F \text{ ratio} = (A \text{ ratio})\frac{pr^2}{(y \text{ ratio})^2} \text{ or } (A \text{ ratio})\frac{p}{q^2r^{2n-2}} \quad \ldots\ldots [9]$$

or

$$D \text{ ratio} = (d \text{ ratio})\frac{p^{1/2}r}{y \text{ ratio}} \text{ or } (d \text{ ratio})\frac{p^{1/2}}{qr^{n-1}} \quad \ldots\ldots [10]$$

$$V \text{ ratio} = (F \text{ ratio})(y \text{ ratio}) = (A \text{ ratio})\frac{pr^{2-n}}{q} \quad \ldots\ldots [11]$$

where $D$ = diameter of surge chamber (assumed circular)
$d$ = diameter of conduit line (assumed circular)
$V$ = volume movement in surge chamber.

We have thus assumed the existence of various structural ratios, of a velocity ratio and of a time ratio, and have derived the relations among these ratios necessary in order that the conditions of homogeneity among the terms of any one equation may be realized.

Suppose now the two systems $A$ and $B$ set up in accordance with these various structural relations. It is then readily seen that we may choose initial conditions of operation which will fulfill

the required relations throughout. That is, at the initial conditions, the requirements for kinematic similitude may be fulfilled by arbitrary adjustment. It is then readily shown that under these conditions the increments of $y$ and $v$ will likewise fulfill the relations for similitude, and hence the succession of values of $y$ and $v$ throughout the entire period of transition.

It thus results with two such systems $A$ and $B$, with structural relations as specified and for which the water movements are in accordance with Equations [1] and [2], that if the conditions of similitude are fulfilled at the beginning of the movement, they will likewise be fulfilled for subsequent times throughout the movement and thus the general conditions for similitude will be realized as assumed.

### Form of Relations for Similitude when $n = 2$

It will next be of interest to note the form taken by these relations if the index $n$ is taken equal to 2, as in the more common methods of treatment of the problem. Referring to [6]-[11], we shall have—

$$y \text{ ratio} = qr^2$$

$$\text{Time ratio } s = \frac{p}{qr}$$

$$\frac{F}{A} \text{ ratio} = \frac{p}{q^2r^2}$$

$$F \text{ ratio} = (A \text{ ratio}) \frac{p}{q^2r^2}$$

$$D \text{ ratio} = (d \text{ ratio}) \frac{p^{1/2}}{qr}$$

$$V \text{ ratio} = (A \text{ ratio}) \frac{p}{q}$$

### Surge Chamber with Spillway

A case possessing both interest and importance is presented by a surge chamber fitted with an overflow weir or spillway at a certain fixed height.

Let $B$ = length of such spillway or weir
$y_0$ = height from datum to level of spillway edge
$y$ = height from datum to surface of water

Then $y - y_0$ = depth of water on weir.

In time $dt$ let the water level rise $dy$

In time $dt$ the flow along conduit line $= vAdt$

In time $dt$ the discharge over the weir $= QB\,(y - y_0)^{3/2}\,dt$

In this formula for weir discharge $Q$ is taken as containing all factors other than $B$ and $(y - y_0)$

We have then—

$$vAdt = Fdy + QB\,(y - y_0)^{3/2}\,dt \qquad [12]$$

or

$$vA = F\frac{dy}{dt} + QB\,(y - y_0)^{3/2} \qquad [13]$$

This equation together with [1] for the acceleration head will serve instead of [2] to determine the motion of the water level after the water reaches and rises above the weir edge.

To apply the principles of similitude to this case we must assume the weir coefficient $Q$ the same for both weirs, field case and experimental set-up. We then note that each term of [13] is a quantity of the order of volume flow. Hence for similitude we must have the same ratio between the two systems $A$ and $B$ for each member of the equation. Thus we have:

$$vA \text{ ratio} = r\,(A \text{ ratio})$$

$$F\frac{dy}{dt} \text{ ratio} = F \text{ ratio} \times y \text{ ratio} \div t \text{ ratio}$$

or reducing,

$$F\frac{dy}{dt} \text{ ratio} = r(A \text{ ratio})$$

whence

$$[QB\,(y - y_0)^{3/2}] \text{ ratio} = r\,(A \text{ ratio})$$

and

$$B \text{ ratio} = \frac{r\,(A \text{ ratio})}{(y \text{ ratio})^{3/2}} = \frac{A \text{ ratio}}{q^{3/2}r^{3/2n-1}} \qquad [14]$$

If in this case we assume the index $n = 2$ we shall have—

$$B \text{ ratio} = \frac{A \text{ ratio}}{q^{3/2}r^2} = \frac{A \text{ ratio}}{q^{1/2}(y \text{ ratio})} \qquad [15]$$

The volume of water discharged over the weir will be given by the expression—

$$V = QB \int (y - y_0)^{3/2}\,dt \qquad [16]$$

We have then—

$V$ ratio = product of individual ratios for expressions making up $V$ as in [16] hence—

$$V \text{ ratio} = \frac{A \text{ ratio}}{q^{3/2}r^{3/2n-1}}\, q^{3/2}r^{3n/2}\, \frac{p}{qr^{n-1}} = (A \text{ ratio})\,\frac{pr^{2-n}}{q}$$

and for $r = 2$,

$$V \text{ ratio} = (A \text{ ratio})\,\frac{p}{q}$$

This is seen to be the same as the volume ratio for change of volume in the surge chamber, as indeed it should be.

### Case with Multiple Surge Chambers

The case with two surge chambers is indicated in Fig. 3 as a

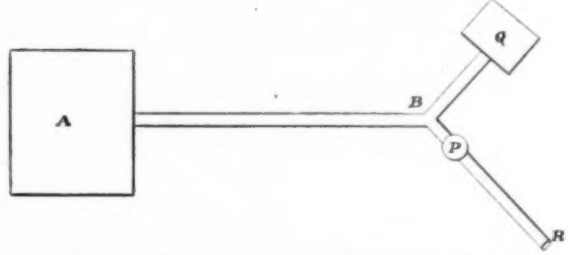



Fig. 3 Diagram of the Case of Two Surge Chambers

plan view. The main supply reservoir is at $A$, a small regulating reservoir at $Q$ and a surge chamber of usual dimensions at $P$ with the power plant lying beyond at $R$. With such an arrangement the reservoir $Q$ functions as a large surge chamber, thus complicating the problem as affecting the movement of water in $P$.

With this combination of elements a disturbance from the conditions of steady flow involves, physically, the problem of three superimposed oscillatory systems; one by way of $ABQ$, one by way of $ABP$ and one by way of $PBQ$. To define these conditions, six equations are required as follows:

$$\text{Motion in } AB,\quad \frac{L_1}{g}\frac{dv_1}{dt} = H - z - c_1v_1^n$$

$$\text{Motion in } BP,\quad \frac{L_2}{g}\frac{dv_2}{dt} = z - y_2 - c_2v_2^n$$

$$\text{Motion in } BQ,\quad \frac{L_3}{g}\frac{dv_3}{dt} = z - y_3 - c_3v_3^n$$

$$\text{Continuity at } B,\quad A_1v_1 - A_3v_3 = A_2v_2$$

$$\text{Continuity at } P,\quad A_2v_2 - F_2\frac{dy_2}{dt} = A_1u$$

$$\text{Continuity at } Q,\quad + F_3\frac{dy_3}{dt} = A_3v_3$$

where $L_1, v_1, A_1, c_1$ = respectively length, velocity, area and coefficient $c$ for $AB$
$L_2, v_2, A_2, c_2$ = respectively length, velocity, area and coefficient $c$ for $BP$
$L_3, v_3, A_3, c_3$ = respectively length, velocity, area and coefficient $c$ for $BQ$
$H$ = total static head from top of reservoir at $A$ to datum at bottom of $P$
$z$ = pressure head at junction $B$ measured from datum at bottom of $P$
$y_2$ = level of water in $P$ measured from datum at bottom of $P$
$y_3$ = level of water in $Q$ measured from datum at bottom of $P$
$u$ = velocity in $AB$ corresponds to new demand in $R$.

In these equations as written, the positive directions of flow are taken as $AB$, $BQ$, $BP$.

Equations of this character and number are quite beyond the range of any practicable mode of mathematical attack, even by way of numerical integration. The methods by way of similitude hold, however, as with the simpler cases, and the model once set up, any condition of operation is readily examined. In setting up the model it is only necessary to use a uniform ratio of length and of diameter or area of conduit. These ratios together with the velocity ratio will then fix the ratio for all vertical distances for time and for the cross-section area of surge chamber.

For a case with more than two chambers the same general principles hold, and any such case may be examined by experimental methods through the use of a model set up with ratios as above. Such cases, however, are not likely to be met with in practice.

For the case of Johnson's differential regulator[1] the same fundamental equations, with suitable interpretation, apply as for the plain open chamber, and under these conditions the ratios and relations will be the same and the performance in detail may be investigated by means of the model method.

## Special Notes on Application of Method

In the application of these methods it should be noted that the assumption of a uniform value of the ratio $q$ does not imply the assumption of the same values of friction coefficient for large and for small pipe. It simply implies that for the large pipe the velocity-friction head may be put in the form $cv^n$, the value of $c$ being constant over the range of velocity involved, and likewise that the similar head for the small pipe may be expressed in the same form, this value of $c$ likewise being constant over the velocity range involved. The ratio between the two values of $c$ will then be the constant $q$ of the formulas.

Also it should be noted that in cases of design the $c$ for the field case will usually be the subject of estimate based on judgment. This, however, is required for any computations or estimates regarding velocity of flow, capacity of line, power, etc., and the one estimate as to friction head will serve uniformly for these varied purposes. On the other hand, the value of $c$ for the experimental model is a matter of direct measurement and in all cases should be so determined. A series of simple measurements of flow, time and drop in level between reservoir and surge chamber will serve as a basis for this determination for the model. Such observations plotted on logarithmic paper provide then a ready means for the determination of the values of $c$ and $n$ for the model, and this value of $c$ compared with the assumed $c$ (with the same $n$) for the field case will give the value of $q$ as noted above.

*Surge Chamber Non-Uniform in Cross-Section Area.* It should be especially noted that with the experimental method, the surge chamber is not necessarily of uniform cross-section area. It may be tapering or of any form at will, so long as the model is made of corresponding dimensions. It should also be noted that the ratios of horizontal and of vertical dimensions are not in general the same. The result will therefore be geometrical similarity between the model and full-sized installation, but not the same proportions between horizontal and vertical dimensions.

It is simply necessary that, at corresponding vertical dimensions as determined by one ratio, the horizontal dimensions are also similar, as determined by the other ratio. This is further illustrated by Fig. 4 showing the relative proportions for a full-sized and a model surge chamber, the former as installed on the line of the Los Angles Aqueduct Power System.

*Governor Action.* At an earlier point in the paper, reference has been made to the various assumptions which may be made regarding the results of governor action during the period of change and to the fact that no assumption which can be made in precise terms will represent the real program in an actual case. Due to the relative simplicity of the equations resulting, however, assumption ($a$) was implied in deriving the basic Equations [1] and [2].

It should again be especially noted that no matter which of these assumptions may be made, the ratios for similitude remain unchanged. Equations of the type of [1] remain the same, while equations of the type of [2] remain the same in form with the substitution for $v_2$ of a velocity $u$ in $AB$, suited to the particular assumptions made.

[1] Trans. Am.Soc.M.E., vol. 30, p. 457.

With ($a$), $v_2$ as already noted is the velocity in $AB$ necessary to give, under final steady-flow conditions, the power required under the changed conditions.

With ($b$), for $v_2$ we must substitute a velocity $u$ defined as the velocity in $AB$ which would bring the water required to meet the new power requirements under the momentarily changing values of available head and the efficiency of the wheel.

With ($c$), the velocity $u$ is defined the same as in ($b$), with the omission of the influence due to variation in efficiency of wheel.

With ($d$), the velocity $u$ is defined as that corresponding to the total flow through the valve, set as specified, and with the momentarily changing value of the available head as affected by the changing level in the surge chamber.

In all of these cases the term $v_2$ or $u$ is a velocity and the ratios for similitude remain the same, being unaffected by these various assumptions.

It therefore becomes a question of interest as to which of these four assumptions can be most easily realized in the manipulation of a model.

It is readily seen that assumption ($d$) most readily meets the requirements. For any specified power development it is a simple matter to determine the volume flow required under the head corresponding to such flow. To realize the corresponding condition with the model requires simply the setting of a control valve at $P$, Fig. 1, in accordance with a previously determined calibration.

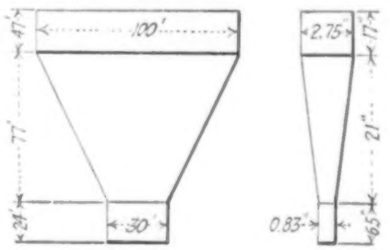



Fig. 4 Relative Proportions for a Full-Sized and Model Surge Chamber

On the other hand, if any of the other assumptions is to be fulfilled by model, the rates of volume flow corresponding to the special conditions must be determined and the setting of the control valve determined therefrom, taking into account the height of the water in the surge chamber. The valve setting will thus depend on such height and hence the valve will require adjustment continuously during the period of transition, corresponding to the rise and fall of the water in the surge chamber.

As a manipulative program it is entirely possible to realize this through the use of a cam form of control, the movement of the cam being determined in step with the movement of the water in the chamber. Such a program of control is, however, somewhat complex in character and adds in marked degree to the time required for making and assembling the model equipment.

In order, therefore, to realize in the highest degree the advantages of the model method, it is desirable to accept assumption ($d$) as representing with a sufficient degree of approximation the operative conditions of the plant. An examination of the conditions of operation of a power plant will serve to show, furthermore, that with supposition ($d$) as compared with either ($a$), ($b$) or ($c$), the resulting conditions as regards surge are more severe and hence that the error will be on the side of safety. It is also evident that the influence of the variation of level of the water in the surge chamber on the general program of volume discharge or of power developed at the power house will be relatively small as the range of such fluctuation is small compared with the difference in level between water in surge chamber and power house and relatively large in the inverse case.

The whole question of the use of a model for the study of such problems turns therefore largely on the degree of closeness to which the manipulation of the model may be made to represent the proposed programs of change in the field installation, and more specifically in the actual power plant; or again on the extent to which the simple model program as indicated in asumption ($d$) may be

accepted as satisfactory for the purposes in view. As indicated above, it appears that, in all cases where the range of fluctuation of the water level in the surge chamber is small compared with the difference in level between surge chamber and power house, the simple program of (*d*) may be accepted as satisfactory for all practical purposes. If such fluctuation should, on the contrary, be large, the use of the model would presumably require such further devices as would make possible a closer approximation of the program of water flow in the model outlet to the actual or proposed program in the power house.

A further point should be here noted, and that is that the model proper in its correspondence with the field case covers only the main supply line and the surge chamber. It does not necessarily extend to the line from the surge chamber to power house. In the model the line from surge chamber to discharge valve may be considered simply as a means for realizing a desired discharge through the setting of a calibrated valve. From this view, therefore, it is simply necessary to have such size of line and such head as shall insure, through the discharge valve, the rates of flow covering the ranges contemplated. At the same time it is generally desirable to give to this discharge line a vertical dimension not widely dissimilar from that corresponding to the field case, in order that the range of fluctuation of the level in the surge chamber may bear to the difference in level between the surge chamber and power plant approximately the same ratio in both model and field cases.

*Special Programs of Change.* In addition to the usual problem as presented by a sudden change in power demand followed by substantially uniform conditions, the model method readily serves for the examination of two types of problem, neither of which is practically susceptible of treatment through computation methods. These are as follows:

1 Required the cumulative result of periodic changes of any specified magnitude and with any specified frequency. Thus for illustration, we might have a proposed program of additions to the load, each of 10 per cent total load, and with specified intervals. If the latter should be such as to bring the load changes into approximate synchronism with the surge-chamber movements, the cumulative results might become very serious; while otherwise the resultant movement would be relatively small. Again, we might have the condition of a surging load, alternate increase and decrease and with any proposed frequency. This again, if in approximate synchronism with the surge-chamber movements, may result in the most extreme and serious conditions in the latter.

All such problems are most readily examined by the model. It becomes necessary simply to determine the change of flow corresponding to the proposed change in power and to note the corresponding settings of the control valve. Then with the corresponding time interval known, it is simply a matter of manipulative procedure of the control valve, with corresponding note of the resultant movement of the water in the surge chamber. In this general manner the results of all forms of varied or periodic programs of change in power demand, or of flow in general, are readily examined.

2 Required the time over which a specified power change should be extended in order that the resultant surge-chamber movement may not exceed a specified amount. Thus with a proposed size of surge chamber in a given case, a sudden change of 80 per cent or of 100 per cent of the load, for example, will perhaps produce a surge-chamber movement resulting in extreme overflow at top, or in the indraft of air at the bottom. In either case it may be desired to determine the necessary duration of a specified load change in order that the surge-chamber movement may not exceed specified limits. As a manipulative program this calls simply for the movement of the control valve between specified stops gradually at an approximately uniform rate and involving such total time interval as will meet the requirements within the surge chamber. Experience of the writer shows that this is readily realized by successive trials, and that, as a problem in manipulation, it presents no serious difficulties whatever. The time interval for the model, thus determined, is then to be multiplied by the time ratio, thus giving the required time for the field installation.

*Experimental Detail.* The experimental program, in general, connected with an investigation of this character is simple and may safely be left to the initiative of the interested reader. A few suggestions on particular points may, however, be acceptable.

The control valve is preferably of the cone or needle type with long taper, so that a considerable stem movement will be required between closed and full open. The stem may be controlled by hand lever or otherwise as most convenient, with, in any case, an index moving over a graduated scale. The valve may then be calibrated for steady-motion discharge or velocity by simultaneous observations of valve setting and weight of water discharged in a given time. Observation of the height of water in the surge chamber for each of these settings furnishes likewise data for a series of values of the friction-velocity head, $cv^n$, for the model. A carefully drawn curve between discharge and $cv^n$ will then furnish a ready means of determining discharge by a reading of water level in the surge chamber. From this point on, the valve settings should be used simply to realize approximately the conditions desired, the actual velocity or discharge being taken as that corresponding to the water level in the surge chamber under steady flow conditions.

For reading the movement of the water in the surge chamber, either a float with stem or a gage glass on the side may be employed. With the latter there is time lag and some correction may be required. The author has found the former method the preferable The stem may be furnished with an index moving in front of a suitable scale and with all usual proportions the movement is slow enough to readily permit the reading of maximum and minimum points.

## Illustrative Problems

I—Suppose an actual case characterized by the following data:

| | |
|---|---|
| Length of conduit, ft. | 20,000 |
| Diameter of conduit (assumed circular), ft. | 10 |
| Upper velocity, ft. per sec. | 10 |
| Friction-velocity head at 10 ft. per sec. velocity (assumed), ft. | 50 |
| Proposed diameter of surge chamber, ft. | 36 |

Suppose now that we propose to use for the model conduit 50 ft. of pipe 2 in. in diameter and that we select arbitrarily a velocity ratio of 2.5. Suppose further that with this pipe set up we find experimentally $n = 1.85$ and $c = 0.1695$.

Then assuming the same value of $n$, we find for the field case $c = 0.706$. We have then—

| | | |
|---|---|---|
| $p = 20{,}000 \div 50$ | = | 400 |
| $q = 0.706 \div 0.1695$ | = | 4.17 |
| $r$ | = | 2.5 |
| $r^n$ | = | 5.45 |
| $y$ ratio | = | 22.72 |
| $t$ ratio | = | 44.0 |
| $D$ ratio | = | 132.0 |
| $D = 432 \div 132$ | = | 3.27 in. |

If then we set up the model in accordance with these dimensions, we have only to carry out the program of velocity change corresponding to the proposed field program, observe vertical movements and times, multiply the former by 22.72 and the latter by 44.0 and we shall have the vertical movements and times to be anticipated in the field case.

II—Suppose that it is proposed to fit the actual chamber with a spillway 10 ft. wide with edge 6 ft. above static level in supply reservoir. What will be the width and location of the model spillway?

The edge will be located at a height above static level in the supply reservoir measured by $6 \times 12 \div 22.72 = 3.17$ in. The width ratio from [14] is 82.9, hence the width is $10 \times 12 \div 82.9 = 1.45$ in.

III—As a further example drawn from actual practice, reference may be made to Fig. 2 with dimensions as follows:

$$AB = 14{,}000\,f \qquad d_1 = 11.25\,f \qquad d_3 = 11.25\,f$$
$$BQ = 1{,}191\,f \qquad d_2 = 10.10\,f \qquad D = 35.00\,f$$
$$BP = 137\,f$$

where $d$, $d_2$, and $d_3$ refer respectively to $AB$, $BQ$ and $BP$.

The area of $Q$ varied with elevation from 120,000 to 150,000 sq. ft., constituting a small regulating reservoir. The following proportions and dimensions were taken for the model:

$$p = 240 \qquad \text{also } d_1 = 1.5 \text{ in.}$$
$$\text{hence } AB = 58.23\,f \qquad d_2 = 1.342 \text{ in.}$$

$BQ = 4.96 f$ $\qquad d_2 = 1.5$ in.
$BP = 0.57 f$ $\qquad r = 3$

By experiment $c$ and $n$ for the model were found to be 0.195 and 1.823.

By estimate, for the field case, $c$ with the same value of $n$ was taken as 0.421.

This gives $q = 2.16$ and $y$ ratio $= qr^n = 16.00$.

We then find from the proper formulas—

$t$ ratio = 45

$F$ ratio = 68,200

This gives $F$ for model = 2.04 sq. in. which corresponds to a circular chamber of diameter 1.60 in.

The same $F$ ratio determines also the model reservoir. This was made as a wooden box with sloping sides, so adjusted as to give, over the possible range of change of level, the proper values of surface area.

The pipe of equivalent diameter 1.342 in. was made by filling in a segment of a 1.5-in. pipe to a point giving the proper area.

This combination of elements, with a suitable discharge valve, completed the set-up of the model. The investigation made possible by this model covered the entire range of flow from closure up to the full flow of 1000 sec-ft. and in both directions, demanded and rejected load. These results are shown graphically in Figs. 5 and 6. Fig. 5 relates to the combination of surge chamber and reservoir, while Fig. 6 refers to the surge chamber in operation alone, the reservoir being shut off.

For the conditions of Fig. 5 the diagram shows the maximum water movement (for the field installation) for the first swing following any sudden change of load in either direction. The vertical scale gives elevation in feet, and the horizontal scale flow of water in second-feet.

The heavy-line curve shows the level of water for steady con-

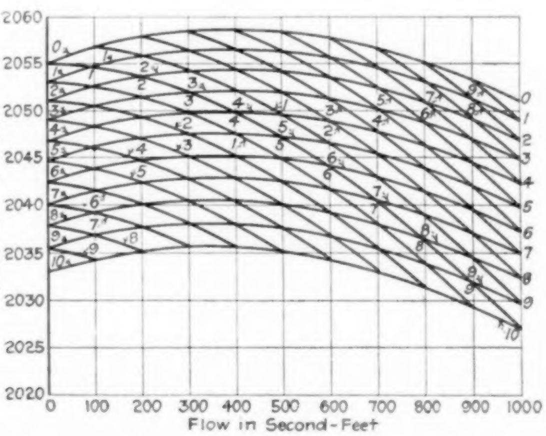



Fig. 5 Flow to be Anticipated with Sudden Change in Either Direction from Any Initial Load $V_1$ to Any Final Load $V_2$
(Surge chamber in combination with auxiliary reservoir.)

ditions for flow varying from 0 to 1000 sec-ft. The diagram shows two sets of curves:

1 Curves running clear across the sheet from left to right and crossing the heavy-line curve.

2 Curves approximately parallel to the heavy-line curve and trending, therefore, downward to the right.

Any problem involves two values of the flow—the initial flow $V_1$ and the final flow $V_2$.

To determine the surge movement for demanded load, go to point $V_1$ on the heavy curve and drop vertically to that curve of set 1 which cuts the heavy curve at $V_2$. The point thus indicated will give the water level for the first surge. If $V_2$ falls between the curves as plotted, the interpolated value is easily read.

Or again, with the plant in operation under flow $V_1$, let there be a sudden demand for an *additional* flow $V$. In this case we may find $V_2 = V_1 + V$ and proceed as above, or otherwise we may go to $V_1$ on the heavy curve and then drop vertically to that curve of set 2 corresponding to the additional flow $V$. The point thus indicated will give the extreme level reached.

In the case of rejected load, the operation is entirely similar except that the curves lying to the right and above the heavy line are to be employed.

In Fig. 6 for the surge chamber alone, the manner of plotting and method of use are the same as for Fig. 5.

These diagrams thus give graphically the results to be anticipated with a sudden change in either direction from any initial load $V_1$ to any final load $V_2$ and for the surge chamber either alone or in combination with the auxiliary reservoir. The influence of the latter in reducing the extent of the surge is thus brought out in a striking manner.

It is perhaps unnecessary to add that the numerical work re-

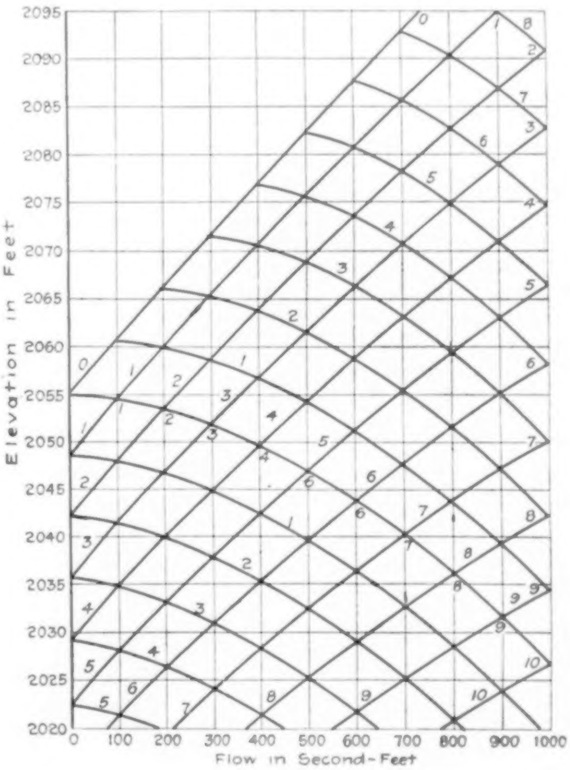



Fig. 6 Flow to be Anticipated with Sudden Change in Either Direction from Any Initial Load $V_1$ to Any Final Load $V_2$
(Surge chamber alone.)

quired to derive corresponding results from the six different equations applying to this case would be entirely prohibitive from a practical viewpoint, and if any investigation is to be made of a case of this character, the experimental model method, using the law of kinematic similitude, as herein set forth, seems to be the only recourse available.

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A 68,750-hp. hydroelectric plant has been installed on the west coast of India by the Tata Hydro-Electric Power Supply Company. Each of the five main Pelton-type turbines comprising the initial installation has a capacity of 13,750 hp. The head is approximately 1700 ft. and the speed 300 r.p.m. The generators, which are direct-connected, are rated at 10,000 kva. and operate at 50 cycles, 6000 volts, three-phase. On account of the climate the extremely high average air temperature of 113 deg. fahr. had to be allowed for in the generator design, so that the 10,000-kva. units installed would, it is estimated, be capable of delivering 16,000 kva. in a more temperate climate. In spite of this condition, however, the generators are said to have shown an efficiency of 95.8 per cent. The long dry spells make water storage necessary, and three large lakes have been made at an elevation of about 1700 ft. above sea level. Power will be delivered at 100,000 volts over a 239-mile line to Bombay, where a large part of it will be used in the cotton mills there. The tailwater will be diverted into canals and will be used for irrigation purposes during the dry season.—*Power*, September 6, 1921.

# Requirements in the Design of Steam Power Stations for Hydraulic Relay

## The Flow or Head Deficiency Type of Relay—Effect of Growth of Load, Seasonal Variation of Flow and Pondage—Relay Stations for Minimum Flow Development and for Higher-Load-Factor Conditions—The Emergency Reserve Type of Relay

By E. B. POWELL,[1] BOSTON, MASS.

SUPPLEMENTAL power in some form is an essential to the commercial development of our remaining unused eastern water powers and, with the possible exception of the Niagara-St. Lawrence system, an essential to the further development of such of these water powers as are now utilized in part. The nature and extent of this supplemental, or relay, power will be governed in a large measure by the character of the stream and the amount, character and location of the load and the importance of continuity in power supply.

In many instances the required relay, at least sufficient for the initial development, may advantageously be provided in the stream itself by adding reservoirs, or merely pondage, to give some artificial control of the flow. In other instances the electrical interconnection of water-power systems, so pooling the water resources of dissimilar streams, may also afford sufficient initial relay in hydraulic power. In general, however, the fullest commercial utilization of water power can only be had by the aid of independent

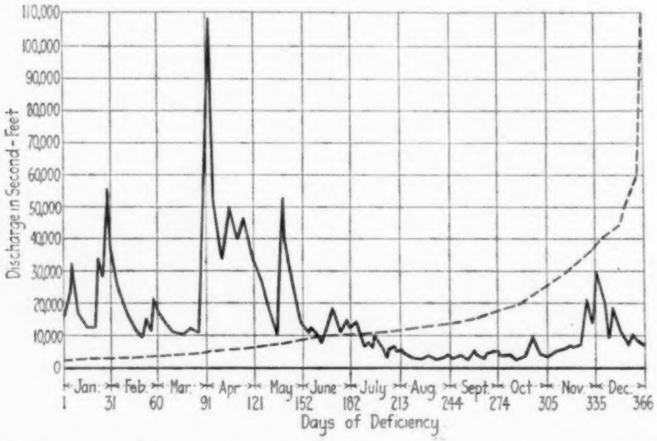


Fig. 1 Daily Hydrograph and Deficiency Curve for 1916, Hudson River at Troy Dam, New York

relay, which in the greater part of the country today is most satisfactorily and economically provided in the steam power station.

The capacity and design of such a relay station should be decided as closely as may be by the particular functions it is intended to perform. The functions of the relay, while they may vary widely, are of two general types, flow or head deficiency make-up and emergency reserve, the second being supplemental to the first. For either type of service the capacity required in any particular case will depend upon the amount and characteristics, initial and prospective, both of hydraulic development and of load. The design, while broadly determined by the usual factors, such as location, power market, water and fuel supplies, fuel costs, which control in the case of the independent central station, is in general, on account of the commonly low load factor, less dependent upon considerations of operating economy. On the other hand, character of load and dependability of delivered hydraulic power are factors of prime importance and, for proper realization of the economic possibilities of the development as a whole, the design should also be governed in many important features by the characteristics of the hydraulic development and the relation of that development to the load.

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Presented at a joint meeting of the Boston Sections of The American Society of Mechanical Engineers and The American Institute of Electrical Engineers, and the Boston Society of Civil Engineers, February 7, 1921. Slightly abridged.

### The Flow or Head Deficiency Type of Relay

Considering first the station intended solely to make up the power deficiencies of the hydraulic development, its functions may include any one or more of the following: seasonal operation to make up deficiencies in hydraulic power from low water or flood; absorption of load growth between stages of hydraulic development; operation as the main source of power. As reflected in the functions of the relay station and as affecting its design, hydraulic developments may be grouped as of four general classes:

I Minimum Flow Development. Developed hydraulic capacity equal to or exceeding maximum system load. Resultant minimum available flow only slightly, and for brief period in the year, below corresponding load requirements. Reserve provided in hydraulic station.

II Medium Flow Development. Developed hydraulic capacity equal to or exceeding maximum system load. Resultant minimum available flow below load requirements for considerable period, 40 per cent or more, of the year. Reserve provided in hydraulic station.

III Continual Relay Development. Available hydraulic capacity slightly below system load requirements throughout greater part of the year.

IV Supplemental Development. Hydraulic development merely an adjunct to the steam power station, which carries the bulk of the load.

The type of reserve referred to in Classes I and II is for relay against failure of equipment within the hydraulic station itself. Under the conditions outlined, this reserve may often advantageously be installed as part of the hydraulic station rather than in the steam station. As is well known, from 50 to 75 per cent of the cost of the average hydraulic development is fixed and independent of the capacity installed, so that sufficient capacity for this type of reserve may frequently be included at comparatively low unit cost.

*Effect of Growth of Load.* It will usually be found that the conditions represented by Classes I, II, and III are merely stages in approach to those of Class IV. This is especially true in the East. However, the change in relative status of the hydraulic and steam power stations may be very slow, particularly so where a series of hydraulic developments may be brought in successively, as warranted by load conditions; in which case to pass beyond the conditions of Class II may require a matter of decades. For these reasons the entire project should be studied broadly in the beginning both as to the ultimate physical possibilities and limitations of the hydraulic development, or developments, and as to the character and probable growth of the market for power. Neglect of such basic analysis in the initial planning of the development risks serious financial loss either in investment or in operating costs.

*Seasonal Variation of Flow.* The seasonal flow of the Hudson River in New York is so variable that the hydrographs of two successive years, 1915 and 1916, with their corresponding deficiency curves may be used in illustrating developments of all four of the classes just referred to. In Fig. 1 it will be seen that if this hydrograph is assumed to represent the year of minimum flow for a particular stream and if a flow of about 3000 sec-ft. would supply the maximum power requirement, a development providing proper equipment reserve at this flow would approximate the conditions of Class I. If growth of load raises the daily power demand above the capacity of the available minimum stream flow and this growth of load is accompanied by a corresponding increase of generating capacity of the hydraulic station to utilize, say, 8000 sec-ft.

with proper reserve, the conditions become those of Class II. Turning to Fig. 2, development of the hydraulic plant to utilize a flow of, say, 10,000 sec-ft. to 12,000 sec-ft. with daily load demands somewhat in excess of the mean available flow, would give the conditions of relay service under Class III. Continued growth of load with a single hydraulic development as applied to either type of stream flow will ultimately bring about the conditions of Class IV.

*Reservoir Storage and Pondage.* Of course, in the case of many streams, it would be feasible to provide sufficient reservoir storage to smooth out the stream flow to a very material extent, thus raising the minimum or primary capacity of the potential development beyond the maximum load demands considered above under Classes I and II at least, and possibly beyond that considered under Class III. For purposes of the present discussion, however, reservoir storage, as distinct from pondage in the usual sense, will not be further considered.

The effect of pondage upon the relay station requirements may be judged from reference to Fig. 3, which shows a typical manufacturing-town load with the "per cent load" curve superimposed for convenience of interpretation. If the minimum flow is assumed equivalent to 50 per cent of the day's energy requirement, with full 24-hour pondage provided, the hydraulic station could take off the upper 70 per cent of the demand, permitting the relay station to carry the base load at a daily load factor approximating 90 per cent with a demand only 30 per cent of the total. On the other hand, in the absence of pondage the relay station must be designed to carry about 75 per cent of the total demand, and on this basis its daily load factor would be reduced to about 40 per cent. It is apparent that, in the absence of pondage, higher capacity will in general be required in the relay station, and the relay-station load factors, both daily and annual, will tend to lower values than where full pondage is provided.

## Relay Station for Minimum Flow Development

Referring again to Fig. 1, it will be seen from the deficiency

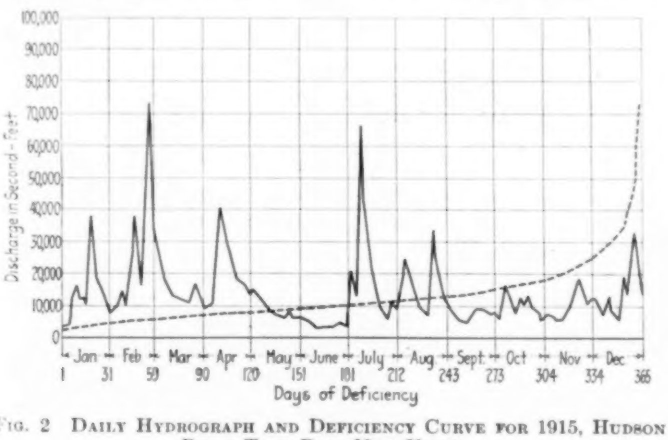


Fig. 2 Daily Hydrograph and Deficiency Curve for 1915, Hudson River Troy Dam, New York

curve that if the maximum load demand is within the capacity of the 3000-sec-ft. flow which is the developed capacity considered for Class I, the relay station except for conditions of equipment failure should not be called upon for operation in excess of 5 per cent of the year. It is not uncommon for relay stations under such conditions to stand idle an entire year. Obviously, for service of this character the actual operating economy of the relay station is of relatively small moment. The important considerations are low fixed costs and dependability.

As the load demands increase and the operating conditions for the relay station approach those of Class II, steam-power production costs are of slightly greater moment but in general are still tremendously outweighed by fixed charges and other costs independent of production. Usually it is only when the conditions of Class III are reached that the annual load factor of the relay station has risen to a value sufficient to make fuel economy as such an important factor in design.

For the extremely low load-factor conditions of Class I, type of equipment, dimensions and arrangement must all be studied with a view to attaining the desired output with minimum investment compatible with simplicity of station and low cost of attendance. Type of combustion equipment and the arrangement of furnace must of course be governed by the character of fuel available.

Coal in its more ordinary form will in general be the most satisfactory fuel. The stoking equipment should be of the forced-draft type for high capacity, either underfeed or chain grate, depending upon the class of coal. Draft facilities should be designed to take care of the maximum rate of combustion that can safely be maintained by furnace and grate over the period of peak load on the station. Economizers cannot be justified for the conditions of Class I, but it may be advisable to make provisions

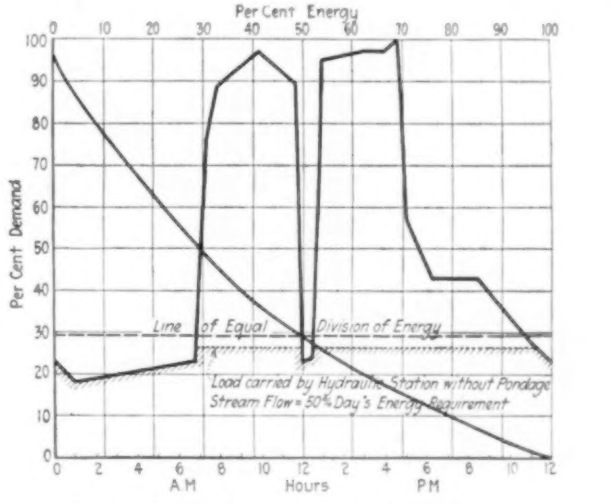


Fig. 3 Typical Manufacturing-Town Load (24-hour load factor, 53 per cent.)

for their later installation to meet higher-load-factor conditions in the future.

The selection of type and size of boiler, decision as to total rated boiler capacity to be installed, and the proportioning of combustion equipment to boiler heating surface must take into account not merely the cost of that equipment only, but also the costs of building and all related equipment such as fuel- and ash-handling facilities, and mechanical draft. The cost curve of Fig. 4 shows that, for the particular case considered, when all related factors are taken into account boiler heating surface may be installed to the comparatively high ratio to grate area of 50 : 1 without appreciable increase of total boiler-plant cost. Higher ratios are accompanied by some increase of cost. The use of a lower ratio will result in needless waste of fuel.

Equally broad considerations should be applied to the design and proportioning of the condensing equipment. Considering the net increment cost of the boiler plant per unit of effective steam capacity and the increment cost of condensing plant for unit change of vacuum at the turbine exhaust, the condensing equipment should be designed to give the degree of vacuum under conditions of the required maximum load which will result in the lowest construction cost for the plant as a whole. In Fig. 5, which deals with a particular set of conditions, curve *A* shows the relative construction costs for condensing equipment to attain different degrees of vacuum, the cost of the 29-in. design being taken as 100 per cent; curve *B*, drawn to the same scale, the increase in boiler-plant cost resulting from the increased total steam demand which is had from different degrees of vacuum less than 29 in.; and curve *C*, which is a summation of *A* and *B*, still expressed in terms of 29-in. condensing-plant cost, the resultant effect upon total station cost, of designing the plant for different degrees of vacuum.

These two charts, Figs. 4 and 5, are correct, as to detail, for the particular conditions only for which they were estimated, but they clearly illustrate the interdependence of equipment costs and the importance of taking all related factors into account in deciding upon the type and size of apparatus. Similar considerations should be applied to the selection of generating units and to the determination of steam pressure and temperature.

Instrument equipment for mechanical apparatus such as boilers and condensers should be complete in so far as required as guides to efficient combustion and to the attainment of the highest degree of vacuum of which the condensing apparatus is capable; not that efficiency in the sense of low fuel rate is of special importance in this service, but that it is an essential to the attainment of maximum output from the major equipment installed which is the prime purpose of the station design.

It will usually be found advantageous to provide electric drive for one complete set of essential auxiliaries to permit starting these without waiting for steam. The main electrical features of the relay station for the Class I conditions will be governed largely by the relation of the station to the rest of the system, provision being made to compensate for line or load characteristics wherever required.

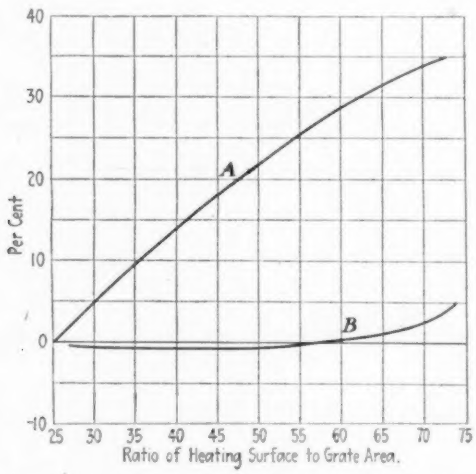


FIG. 4 BOILER-PLANT CONSTRUCTION COST AND CAPACITY AS AFFECTED BY RATIO OF BOILER HEATING SURFACE TO GRATE AREA

A—Increase of steam capacity per sq. ft. of grate area
B—Difference in cost of boiler plant per unit of steam capacity
(Costs and capacities expressed as percentages based on ratio of boiler heating surface to grate area of 25:1 for a particular case.)

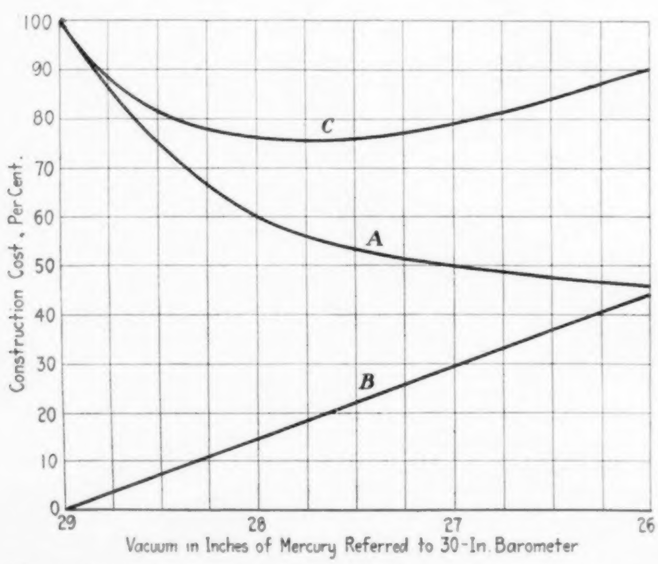


FIG. 5 RELAY STATION CONSTRUCTION COSTS AS AFFECTED BY CAPACITY OF CONDENSING EQUIPMENT

A—Cost of condensing equipment
B—Increase in cost of boiler plant
C—Resultant effect upon total station cost
(All costs expressed as percentages based on cost of condensing equipment designed for 29 in. vacuum and 70 deg. cooling water for a particular case.)

## Relay Station for Higher-Load-Factor Conditions

As the system load grows, if the period of relay-station operation is permanently lengthened, taking the development into the conditions of Class II for example, the higher load factor on which it may be possible to operate any new equipment may justify greater consideration of actual operating economy, condensing equipment may be of more liberal design, and boiler capacity may be added in greater ratio to steam demand, so permitting reduction of combustion rates.

Further growth of load and extension of the operating period for the relay station into the conditions of Class III will justify in new equipment still further consideration of operating economy; until, as the conditions of Class IV are reached, practically the same factors govern as in the usual independent type of central station.

As may be inferred from this outline of the progressive extension of the relay station to keep pace with the system's requirements, the relay station properly designed for low-load-factor conditions may be readily converted to a high-load-factor station, and so converted should operate as such with but a fraction higher total costs than the station specially designed for the higher load factor.

Fig. 6 shows the power costs from two types of station operating on the same conditions of load. Station A is designed initially for relay service under Class I conditions. Improvement in load factor is accompanied by the installation of such additional equipment and of such economic characteristics as may be warranted. Station B is designed for continuous operation at 50 per cent annual load factor. Its first cost is nearly 50 per cent higher than that of the initial step of station A and, while more economical at the load factor for which it is designed, on the lower range of load factors the higher efficiency of its equipment is insufficient to balance the higher fixed charge. Accordingly, where there is doubt as to the actual load factor at which the relay station may be called upon to operate, it will in general be advisable to design for the minimum probable load factor rather than risk unnecessary expenditure in providing for load conditions that may require years to attain.

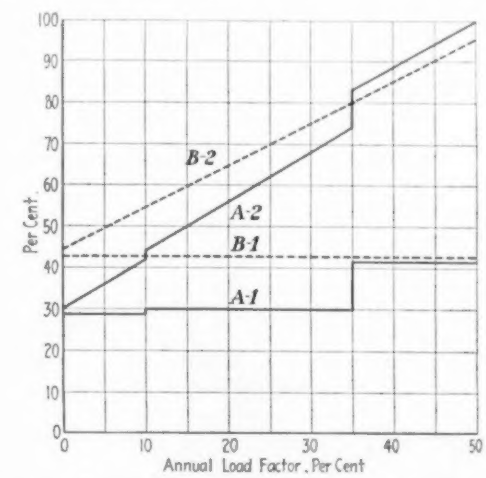


FIG. 6 ANNUAL POWER COSTS OF STEAM RELAY STATION AS AFFECTED BY LOAD FACTOR FOR WHICH PLANT IS DESIGNED

A-1—Annual fixed charges } Class I Relay Station
A-2—Annual total power cost }
B-1—Annual fixed charges } 50% Load Factor Station
B-2—Annual total power cost }
(All costs expressed as percentages based on total power cost for Class I relay station developed for 50 per cent load factor and operated at 50 per cent load factor.)

If the fundamental design is right, the initially high operating charges characteristic of the low-load-factor station are readily outgrown, whereas the fixed charges, essentially higher for the high-load-factor station, are inescapable and remain until amortized a permanent burden on the development.

## Emergency Reserve Type of Relay

Turning now to the station which must also function as an emergency, or breakdown, reserve, the emergency service required of such a station may vary from floating capacity for instant availability to merely providing against interruptions of several hours or days. The requirements in any particular case will be governed in a large measure by the character and importance of the load served.

(Continued on page 674)

# The Rising Importance of Oil-Injection Type of Internal-Combustion Engine

## A Review of the Development of the Internal-Combustion Engine From the Early Gas-Burning Type to the Present-Day Injection Engine Capable of Operating on Any Form Of Liquid Fuel Without Explosive Shock

By CHARLES E. LUCKE,[1] NEW YORK, N. Y.

ALL engineers are interested in the internal-combustion engine, whether directly concerned with its development or not, because it does stand for the highest efficiency in the transformation of heat into work. It is the most efficient prime mover with heat as the source of energy. Its promise of high efficiency on fundamental grounds is very old, but it is only within the present generation that hope has become even an approach to reality. Commercial success has become real in more and more fields of use and application all the time, and today we are able to appraise the situation as never before.

During this period the steam turbine has gone through its own period of development, and at this time when its limit of efficiency is in sight, the internal-combustion engine is actually twice as efficient, with the promise of more to come, in engines of good design and as favorably operated. Even with poor design or unfavorable conditions of operation the internal-combustion engine as to efficiency is practically as good as the best steam turbine of very much larger size.

Recognizing these facts, it is not difficult to understand the real and continuing interest in this problem of commercializing the internal-combustion engine. At the same time it is not at all clear just why it has developed along certain lines and not along others. Development along gas-engine lines—engines burning gas—has been a disappointment, and, taking the world as a whole, the gas-burning engine has not been much of a financial success.

In spite of such a discouragement, however, the internal-combustion engine has gone ahead and is today becoming a dominant, if not the dominant, new factor in transportation. Where it has failed in stationary practice with gas as a fuel, the reason is to be found in its high first cost and maintenance charges as against the low first cost and maintenance charges of the steam-turbine plant, which factors do not equalize through fuel saving unless the fuel cost is very high per unit and the load factor also high, conditions which have not generally obtained. On the other hand, in the transportation field the liquid-fuel applications are the ones that have come into favor because of their peculiar adaptability and the impossibility of competition by the fixed steam and hydraulic central stations on land. Even on the sea we find the motorship making very substantial headway against the steamer equipped with our most modern turbines.

### Rise of Importance of Liquid-Fuel Development in the Combustion-Engine Field

This phase of the problem—the rise of importance of the liquid-fuel development in the combustion-engine field—is worth while analyzing. It is important for all engineers to know something about the business and problems of others, and on this assumption there should be general interest in the story of the adaptation of the internal-combustion engine to the uses of liquid fuel, so as to aid in the adaptation of the engines thus developed to transportation by the motorcycle, the automobile, the motor truck, the tractor, the railroad car or locomotive on land, by aircraft, and on the water by the motor boat and the motorship—in addition to certain stationary uses.

The first successful commercial machines of the internal-combustion class were gas-burning engines. While they have now sunk into a condition of more or less commercial insignificance, they have left behind a useful influence in that they have taught certain lessons that are of value in solving the problems of liquid-fuel adaptation.

The first lesson taught by the gas-burning engine is, the higher the efficiency the higher must the compression be. That is as it should be on thermodynamic grounds, and experience has amply demonstrated the validity of the theory. The second lesson is, that in addition to high compression, high efficiency is obtainable only if combustion is carried out in a correct and proper manner as to timing and rate. The gas-burning engine has also demonstrated that to get the maximum results in both power and efficiency it is equally necessary that the fuel be intimately and homogeneously mixed with the air throughout its entire mass, and that the cylinder be fully charged with that kind of mixture.

In addition to these principles of combustion for transforming high percentages of heat into work, the building of gas-burning engines has established many basic principles in the structural problem. To make cylinders, pistons and heads that will not crack is not as easy as it would seem, but taking the experience of the world at large, it can be said that reliable means of avoiding cracks have been devised.

In the adaptation of liquid fuel there are certain special problems that have to be faced that did not exist with the gaseous-fuel internal-combustion engine. The two principal classes of problems are in the fuel itself and in the special type of service to be met. It very early appeared there could be no such thing as a universal liquid-fuel engine equally good for gasoline, kerosene or fuel oil, or equally good for boats or automobiles or aircraft. There might very well be an automobile engine or a motorship engine, or a tractor engine, or a railroad engine, or a stationary electric-lighting-set engine, but each must be different.

It is this adaptation that occupies most of the period of development. To study the fuel phase of liquid-fuel adaptation, fuels must be divided into the two classes that are now found commercially but which division originally was not so clear. The first class includes fuels that are sufficiently volatile to make a more or less homogeneous and gaseous mixture with air by passing through so simple a device as a carburetor, which is similar to the older air-gas mixing valve of all gas-burning engines. The second may be termed the non-volatile class, and it includes anything that cannot be used in such a carburetor with or without heat, but which requires a device that must be built into part of the engine structure rather than a device or attachment to what would otherwise be a gas engine, thus initiating the injection oil engine.

The really difficult problem of the gasoline engine appears only when it is realized that the fuel available is no longer volatile enough to make the desirable homogeneous mixture, but not yet bad enough to require an injection engine. Before getting down to the problem of the injection engine proper, however, it is desirable to analyze some of the difficulties encountered in adapting the gas-burning engine and its principles of good utilization to light, and then to heavier, gasoline.

### Difficulties Encountered in Adapting the Gas-Burning Engine to Light and Then to Heavier Gasolines

The first principle of maximum compression cannot be carried as far as is desirable because the ignition temperature of these gasoline mixtures is lower than that of the gases forming the bulk of the fuels for the more efficient gas-burning engine. Furthermore, the temperature of the mixture before compression is no longer under the complete control it used to be with cold gas, and the temperature at the point of ignition or when compression ends

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is as much a function of the temperature before compression begins as it is of the amount of pressure rise.

The conclusions reached in gas-burning engine practice with regard to mixture quality, proportionality, homogeneity, intimacy, are all verified with gasoline. In proportion as that kind of mixture is attained with the volatile liquid fuel, so is it possible to attain some fair measure of the promise of efficiency, but the limit of attainment and the realization of it both fall off as the volatility falls off, and with the gasoline we are now using approximately only one half vaporizes in the intake passages.

The other half that will not vaporize is carried along in three different states: (*a*) as a film on the walls, such as rain will form on a window pane, (*b*) as a fog that floats, and (*c*) as a rain that is falling or driven by the air currents. A fog turns into rain, the

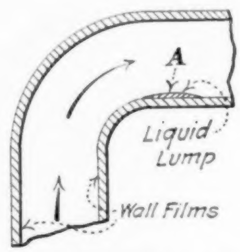



Fig. 1 Gasoline-Kerosene Carburetor Engine, Liquid on Manifold Walls

rain makes films and the action cannot go far before the fuel is all wall film. No amount of ingenuity with devices such as screens, baffles and paddles can prevail, because these cannot overcome the laws of liquid flow and vapor pressure that are operating. This is a problem of serious importance, because if the unvaporized liquid fuel gets into the cylinder and strikes a hot spot, such as the piston head, it will vaporize there locally, and will form on the piston head a "pancake" of vapor that will have displaced the air and not be mixed with it. This when combustion takes place above it, is simply heated to decomposition temperature, producing carbon, and though actually not burning itself, it fouls up the engine and interferes with its operation with a loss of fuel.

If the unvaporized fuel entering the cylinder strikes on a cold cylinder wall, it will run down past the piston into the lubricating oil. This unvaporized fuel is mainly kerosene and the lubricating oil is also a petroleum product. They are mutually soluble and as a consequence the viscosity disappears. The mixture is no longer a lubricant. It runs down into the crankcase and destroys the lubrication of the main bearings and the crankpins, as well as the piston pins. How can these things be prevented from happening? Unless they are prevented, the engine is no longer commercial.

Two courses of action are open. The first is to heat the mixture as it leaves the carburetor, and thereby raise the vapor pressure to a point where in a 15 to 1 proportion there will be a vaporized-fuel and air mixture at the minimum possible temperature and a pressure of one atmosphere. It may be said, therefore, that a moderate amount of heating is permissible, and possibly a sufficient amount to completely dry the mixture if the gasoline is not too heavy, but complete heating for a kerosene mixture is not. Gain will be realized, but also a loss, and the loss will overbalance the gain, and the practice must be abandoned.

The next mode of attack is to try to handle the mixture with some of the fuel as a liquid. To handle a wet mixture means really, in the modern multi-cylinder engine, to distribute the stream of liquid as it runs along on the inside of the pipes, to four, six, or more branches, giving to each the same amount of liquid in order that all cylinders may work the same, assuming the liquid will be vaporized or sprayed as it enters each cylinder. To accomplish this it is necessary to know how the liquid moves. Imagine the liquid coming up the side walls of the riser and approaching a bend as in Fig. 1. How would it turn? Observations in glass show that the liquid forms a very substantial lump at $A$, just beyond the turn, and on the inside of the bend. Films collect at the outside of the bend, but the velocity of the air-vapor mixture is so great at that point as to drive the liquid film around the bend to the point, of least velocity. It is really the shape of the stream of air that the plug of liquid reveals.

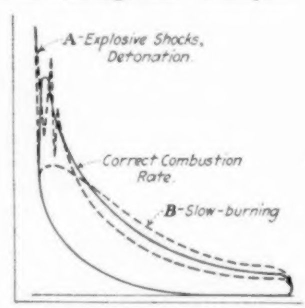
Therefore, if the gasoline is not very heavy, then a moderate heating of the mixture—not too much—with some form of hot spot is the right thing so as to avoid preignition, and with this moderate heating a manifold to take care of the distribution of the rest of the liquid.

### Remedies Proposed

The net result of all this is that the gasoline carburetor engine is approaching a crisis in its history that is going to force the use of radical remedies. The remedies now being considered are as follows:

First, the elimination of the manifold entirely. This will take away the distribution problem and will permit the delivery of the liquid as a liquid with its air into the cylinder directly. No particular nozzle spraying is needed and not much vaporizing, because by properly forming the inlet valve and its passages a combustible foglike mixture will be formed as the charge enters the cylinder. This method has proved to be successful, and it is now the standard in use for all farm and most tractor engines, several hundred thousand of which are made every year, burning kerosene without any mixture heating whatever beyond what is incidental to suction.

Lubricating-oil contamination still is troublesome, and all such engines suffer from it to a greater or less extent. To minimize this the cylinder lubrication must be kept separate from that of the main bearings and crankpins. With admission of the mixture,



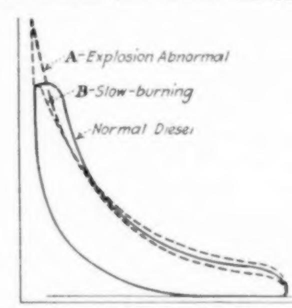




Fig. 2 Injection Oil Engine—Explosive Combustion
Fig. 3 Injection Oil Engine—Non-Explosive Combustion

however poorly vaporized, directly to the cylinder, good mixtures can be made without reduction of compression, but it is actually increased by adding water. This allows the water to enter the cylinder as a spray, just as the kerosene does, and by reason of its thermal, and to some extent its chemical, action, the compression can be raised so that some tractor engines and many farm engines have as high as 90 lb. compression.

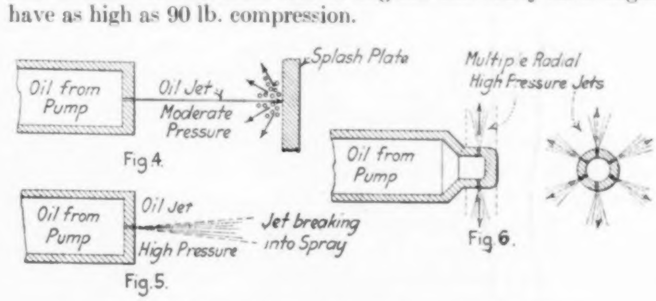



Fig. 4 Hornsby Jet-Splash Spraying Device
Fig. 5 High-Pressure Jet Breaking into Spray
Fig. 6 Multiple Radial High-Pressure Jets Breaking into Spray

The second remedy is to change the volatility of the gasoline by mixture with another and more volatile fuel. By properly selecting the things to be added to the gasoline, it is possible to not only improve the volatility, but at the same time raise the ignition point. Experiments with a benzol-alcohol-kerosene mixture at Columbia University have yielded truly wonderful results judged by the possibilities of the future. It is amazing to what extent compression can be raised on a charge of gasoline ready to preignite normally, with a minor amount of alcohol added. This is also true with benzol. Such mixtures carried the German aircraft through the war.

### Abandonment of the Carburetor Engine as a Means of Solving the Present Motor-Fuel Problem

The third remedy—and this is the radical thing—is to abandon the mixture engine entirely and take up the injection engine. The abandonment of the carburetor engine, or the complete premixture engine, is a thing that would solve the present fuel problem as we hear of it, and that fuel problem is a real problem. America is today facing a situation in its liquid-fuel supply that is one of the most serious things that has happened industrially. This country has reached the point where imports exceed exports. That means a real shortage. It is due to the motor-car and allied demand. Its direct effect is increased prices for those volatile constituents that are in greatest demand, but without a corresponding increase in price for such residuals as are not in demand. A switchover from the carburetor engine, which requires the light distillates, to an injection engine—independent of the distillate and of a kind which is independent of volatility, operating with anything having proper fluidity—would mean that the automobile industry would be revolutionized. Such a step cannot be taken suddenly. It is a difficult job, but it is possible to explain the difficulties and to state the progress that is being made in solving them. Not only is this a matter of interest to the engineer, but it is a matter of national importance.

In case of the successful development of a suitable injection engine the problem of gasoline shortage disappears, because the injection engine can handle any petroleum distillate, any coal-tar product, any alcohol or similar fuel, subject to the one condition that it shall be of proper fluidity to pass the pump valves and spray finely at the spray orifice. If a fuel is not naturally of high fluidity, there is not one that cannot be made of proper fluidity by adequate heating. The temperature of heating, however, must not be carried so far as to cause a decomposition with carbonization and cracking.

### Injection and Carburetor Engines Compared

The injection engine, compared with the carburetor engine, not only makes engines independent of the grade of fuel (there is only one requirement besides its viscosity—cleanliness), but it presupposes that there will be under compression only air, and that only after compression shall the fuel be injected. This means that by properly choosing the time of injection the compression may be as high as pleases the designer. There is no longer any limit of temperature of ignition, because there is nothing to ignite. As a consequence the injection engine has higher possibilities of efficiency, and those possibilities are attainable, and attained.

Another difference found between the injection and the carburetor engine is that due to the difficulty in making the fuel reach all of the air. With the gas-burning engine and with the carburetor type of volatile-liquid-fuel engine, a mixture is made externally and every part is actively combustible, so that there will be the maximum possible work per cylinder charge for a given compression and shape of combustion line. With the injection engine there are certain real advantages, as pointed out, but if after compression of the air charge the fuel is quickly thrown in, it will be difficult to reach all of the air in an unfavorably shaped combustion chamber from a single point of injection.

There must be a means of spraying the oil into a charge of dense air—air of a density up to 30 or 40 atmospheres means of arranging to get the injected fuel in contact with as much of the air as possible, and means of preventing the delivery at any point of any considerable amount of fuel that cannot reach air, because in that case carbon will be formed and smoke produced which will choke up the engine in time.

### The Two Classes of Injection Engines

The means of carrying out the operations that are peculiar to the injection engine are divisible functionally into two classes. The air must always be compressed. It may be compressed to ignition temperature and higher, so that the fuel as injected into it ignites immediately and burns as fast as it gets in, the rate of combustion being the rate of injection and controlled by mechanical means. On the other hand, it may be compressed not to ignition but to something less than ignition temperature, and then the fuel injected suddenly to form an explosive mixture which will burn as nearly instantaneously as may be. This gives us two classes of injection engines. The first, the correct operation of which is shown in the indicator card of Fig. 2 in full lines, is explosive in type, and if the combustion is imperfectly carried out there may result explosive shocks as shown at $A$, or slow burning as at $B$ in dotted lines; the other, shown in Fig. 3, carries the air to a higher compression pressure, so as to have it not only as hot as the ignition temperature but somewhat hotter. This will give a non-explosive combustion at substantially constant pressure according to the full line, but if combustion be carried out imperfectly, or deranged as to timing of injection or combustion, it may produce explosive shocks as at $A$ or slow burning as at $B$ according to the dotted lines.

Each of these two classes is subject to certain derangements or diseases peculiar to a given mechanism, but comparing the two properly adjusted, how do they stand with reference to each other? Is there any great choice, any reason why the advocate of one should call the advocate of the other wrong? Not at all. Each is justifiable on the grounds of efficiency, power and practicability, so that the real problem boils down to one of mechanical questions of relative cost, reliability, foolproofness and adaptability to service conditions. The two are related in this simple manner as to efficiency. If the compression of the first with explosive-type combustion is about half the compression of the other burning the fuel at substantially constant pressure, their efficiencies are substantially the same. In the former case, if an explosive mixture is to be made, the compression must be kept $X$ degrees below the ignition value in order to keep it under control, and in the other case $Y$ degrees above ignition temperature to insure prompt ignition after injection.

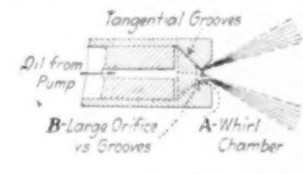



Fig. 7 Single-Orifice Whirl-Chamber Spray Nozzle

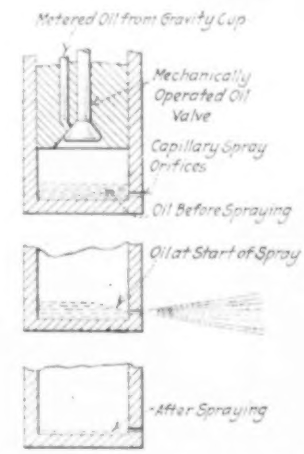



Fig. 8 Hvid Air-Spraying Cup

Assuming the exponent $n$ in the equation $PV^n = C$ to have a value of 1.4, it appears that 150 lb. compression will produce the ignition temperature of kerosene (998 deg. fahr.) if the initial temperature is a little less than 250 deg. fahr., and if an explosive mixture is to be formed and not preignited, a margin of 100 deg. below ignition will be attained with an initial temperature of something under 200 deg. and a margin of 200 deg. with about 175 deg. fahr. initial. For fuel oil having an ignition temperature of 1070 deg. fahr. the same conditions will be brought about by the same compression when the initial temperatures are 300 deg. fahr., 250 deg. and 200 deg. respectively.

On the other hand, if the air is to have a safe margin of temperature over the ignition value before compression, higher compression or higher initial temperatures are necessary. For solid-injection sprays it is generally assumed that 200 deg. margin is safe and for air spraying 400 deg. margin. For the latter case a compression of 450 lb. is pretty generally adopted, and this will be secured with a little over 250 deg. initial with kerosene and a little less than 250 deg. with fuel oil. Solid-injection ignition may be produced with equal reliability with less compression, or with lower initial temperature, or both.

### Methods of Spraying Fuel Employed in Injection Engines

The first mechanical problem in connection with this injection engine is that of making the spray, and one might say, in a way, that the building of the engine begins with the forming of a chamber around a spray. The simplest way of making a spray nozzle, introduced by the first successful commercial engine which was brought here from England—the Hornsby—consists in drilling a hole in a plate. Through this a jet is projected which strikes the wall, a spray being formed by splashing (Fig. 4). If the hole is

reduced in size, or if supplied with oil under much higher pressure, the oil will move proportionately more slowly on the sides as compared with the center, and finally the entire jet will expand into a fine mist (Fig. 5).

The essential characteristic of such a spray is strong penetration power. What is necessary, however, is some means of spreading. This can be secured by multiple holes (Fig. 6). It can also be secured by using slots which are normally closed but which are opened by the oil pressure deflecting the metal. Spread can be secured also from a single spray orifice by giving the oil back of the orifice a rotary motion just as in the mechanical atomizer oil burner as developed for the Navy (Fig. 7). Here the oil grooves are arranged to deliver tangentially into a small whirl chamber *A*, so that the oil in the chamber will have a rotary motion, as also will the oil issuing from the end of the orifice *B* at the outlet from the chamber. If the orifice *B* has an area many times greater than the area through these grooves, there will be no residual pressure in the chamber *A*, and in this case with sharp edges oil spray will issue in a hollow cone form, due to a pure centrifugal whirl. The spray will have a good uniform spread with little or no penetration. If, however, orifice *B* be narrowed down so that it is smaller than the grooves in area, there will be residual pressure in the whirl chamber *A*, producing axial velocity also, and the cone spray becomes narrower and solid. The spray will then have less spread and more penetration.

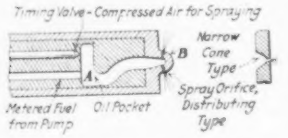



FIG. 9 AIR-SPRAY VALVE, OPEN TYPE

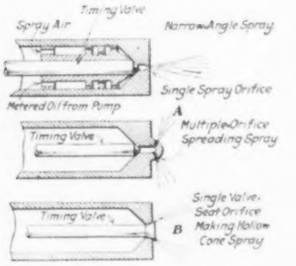



FIG. 10 AIR-SPRAY VALVE, CLOSED TYPE

In addition to this method of solid-injection spraying there is the air-spray system. This in its simplest form (Fig. 8) consists of a cup with liquid fuel in the bottom, compressed air above the fuel, and a small hole in the side at or below the oil level. As the air escapes through the hole there is first a depression of the liquid right at the point and the liquid is carried to the orifice by the air flow across its surface and blown out, being sprayed by the higher velocity of the air. Such a spray is fine and has good penetration, but not much spread.

A modification giving somewhat better control is shown in Fig. 9, which has a depression in the passageway at *A*, in which the fuel is deposited as a pool. A deflector over the oil directs the air down and across its surface. The air in motion will tear the liquid off from the surface and this may be delivered to the cylinder in a narrow cone spray through a contracted orifice *A*, or through multiple orifices as at *B*, to get an adequate spread. This form is the so-called "open air spray" of the Diesel engine.

Next there is the so-called "closed air-spray valve," in which a valve seats on the outlet of a passage as in Fig. 10, and which when lifted allows the air to flow. The oil is delivered by the pump into the passage and spreads out on plates usually provided with holes, grooves, or slots so as to offer a large amount of surface to be wetted by the oil, which can be blown off gradually and delivered as a spray through a single or multiple orifice *A*. Such a spray has a narrow angle, strong penetration, and little spread except as may result from impact and rebounding. This is the most common air spray of the Diesel engine. To secure more spread directly, the valve can be reversed in seating as in *B*.

For any give form of spray, air or solid, there must be a suitable combustion-chamber form, or for any given combustion-chamber form there must be selected a spray of suitable shape or energy to best reach distant air, with always the possibility of setting up turbulence or internal air currents as a corrective means.

### Diesel Engines and Their Limitations

The first class of engines to be noted under the injection type is the one that is most successfully used commercially—the air-injection Diesel engine—and which normally has about 450 lb. compression—more than is sufficient to ignite an ordinary oil, enough more to be safely above ignition temperature all the time. Such engines are normally rated at 70 lb. brake mean effective pressure but are capable of producing over 100 lb. if the metal can stand the intense heating. A fuel consumption of from 0.4 to 0.45 lb. per b.hp. per hr. is standard. They are built in all except very small sizes with cylinders up to about 36 in. diameter, depending on speed and mean pressure. The maximum size is limited by the same internal heating conditions with tendency to crack the metal as obtain for large gas engines. The air-compression Diesel engine is in successful use, as is well known, for both stationary and marine purposes, and is the standard oil engine in use for large ships.

Certain limitations of the air-injection Diesel engine make it unsuitable as a substitute for the gasoline engine. It cannot be made to work with cylinders of too small a size without abnormally high compression, because of the cooling conditions that exist during compression, and in the smallest practical size it is too expensive and too complicated. The control of the air spray is peculiarly delicate. The air for it must be provided by an attached air compressor, and it requires a pressure of never less than 600 and often 1300 to 1500 lb. per sq. in. Such a compressor small enough for the purposes of an automobile is a mechanical absurdity. The particular field to which the air-injection Diesel is not at all adapted, therefore, is that of the small-cylinder high-speed engine, and that, in the internal-combustion market, is the biggest field of all.

### Desirable Features of Semi-Diesel Engines

To approach the problem of the small injection engine, what is available as a starting point? The nearest thing is a type of engine that has been on the market for some time and which is commonly known as the semi-Diesel. These have a feature particularly attractive in the small-engine field—that of operating with so-called "solid-injection or airless spray" that eliminates the air compressor and the delicacy of adjustment of an air-spray valve system. They are simple, but do not operate nearly so well as the air-injection Diesel engine. One feature of this class is hot metal, which plays in these engines the function of more or less vaporizing the fuel and also and mainly that of ignition. This hot metal, when an external wall, is always a fire risk. On a ship it may be serious and in many buildings it is prohibitive. A hot-metal combustion chamber is practically an auxiliary pressure-enclosing wall and thereby constitutes an element of some danger of breakage. The temperature of the hot metal is difficult to control within proper limits, and sometimes impossible.

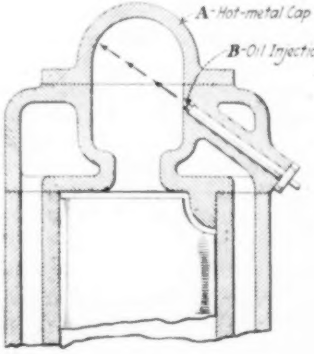
These semi-Diesel engines of hot-bulb, plate or tube pattern cannot be described in detail because of lack of space. They differ from each other mainly in the hot-metal form, or location, and the combustion-chamber shape with reference to oil injection. An unjacketed cap *A* (Fig. 11) more or less hemispherical, closing a water-jacketed chamber connected to the cylinder by a neck, with an oil-injection nozzle *B* arranged so the jet strikes the hot cap to produce ignition by contact, is typical of a group of engines that started with the Hornsby.

### Cold-Wall Explosive-Combustion Solid-Injection Engines

As a result of a fairly general knowledge of the conditions surrounding these so-called solid-injection semi-Diesel engines, attention has been directed toward substitutes that would have some of the good qualities they had—simplicity, cheapness, foolproofness—as well as the good properties of the Diesel—cold walls, ignition by compression, and cleaner combustion with greater independence of fuel quality. Efforts to produce a cold-wall engine are directed along both lines. One is the explosive-combustion engine; the other, the non-explosive-combustion engine. Cold-wall explosive-combustion solid-injection engines are comparatively new. The British Crossley (Fig. 12) has a piston with a conical end and a cylindrical projection *A*. The cylinder head is completely water-jacketed. As the piston approaches the head, the projection *A* will pass the corner of the cylinder head, at which time the air in the annular space *B* is trapped. This projection is a loose fit but not too loose, so that during the time it is passing into the head bore there is a violent annular stream of hot compressed air cylindrically distributed down the sides of the combustion

chamber and back along the center. Into that stream of air is injected a fine spray of oil that is instantaneously ignited, burning as fast as oil and air come together. The combustion is explosive in type but not in fact.

An American representative of the same class of engine is found in the Price construction (Fig. 13), which works differently and in which the combustion is normally explosive in fact. Here a fine spray is injected into a conical combustion chamber *A* on each side of a central cylindrical chamber *B*, up which a gentle air current rises during compression. This serves to help mix the fine spray with the air during the last of the compression stroke. Compression is adjusted so that the ignition temperature is reached just before the end, and as the air charge before compression is cooler at no load than at full load, the misfires that would happen, due to failure to reach ignition temperature, are prevented by an air throttle having the effect of retaining enough hot burnt products to avoid misfires. Should the air charge get too hot from any cause, the whole charge might be ignited everywhere at the same time before compression was complete, producing a detonating combustion with explosive shock. Later injection would correct this if the charge were hot enough or compression high



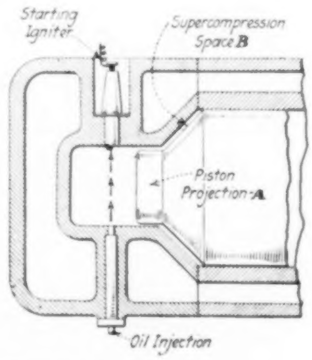
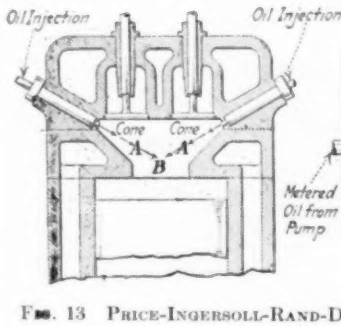




Fig. 11 Hornsby Type of Combustion Chamber

Fig. 12 Crossley Cold Combustion Chamber



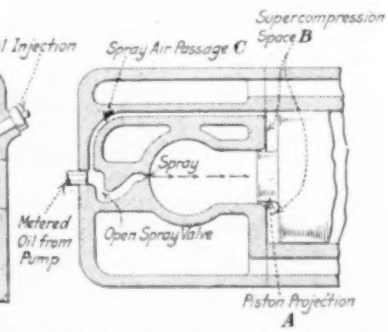




Fig. 13 Price-Ingersoll-Rand-De La Vergne Cold Combustion Chamber

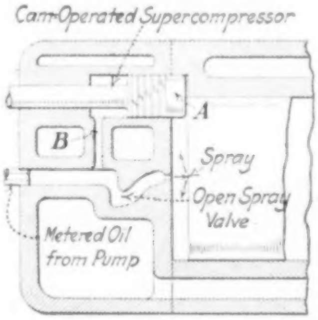
Fig. 14 Haselwander Cold Combustion Chamber

enough and make the action like that of the Crossley engine, where timing of injection is depended upon to prevent detonating shocks, as is spark timing in mixture engines burning gas or gasoline.

These engines are real modern improvements. They can, with a comparatively moderate compression—200 to 250 lb.—give a fuel consumption that is substantiallly equal to the Diesel with its 450 lb. compression, but they must deal with a real difficulty. The combustion is essentially explosive combustion in fact or in type, and with explosive combustion not correctly timed—a little too early or too fast—detonations, either regularly or intermittently, are almost sure to occur. The shocks due to these detonations constitute one of the objections, and this has led other designers and investigators to devote their attention to a new class of solid-injection Diesel engines with non-explosive combustion in cold walls, the attractive features of which are less or no tendency to detonate, greater ease of maintaining correct combustion, and equally good fuel consumption.

## Solid-Injection Diesel Engines with Non-Explosive Combustion in Cold Walls

An early attempt to eliminate the air compressor from Diesel engines was made by the German Haselwander, as shown in Fig. 14, which is practically a Diesel engine with air injection but without a compressor. An open type of air spray is combined with a piston construction embodying a cylindrical projection *A* that traps air in the space *B*. A passage *C* leads this air around to the spray nozzle. The end of the piston supercompresses part of the charge of air, driving it over the fuel and causing it to deliver a spray into the cylinder. The difficulty is that there is no control of timing. Any change in the leakage between the piston



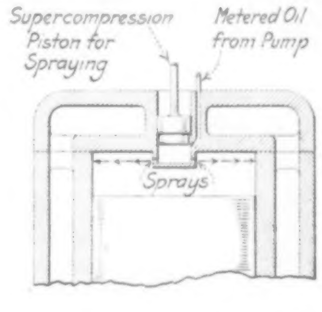
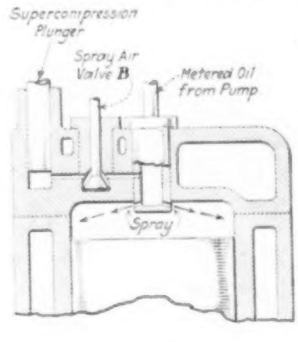




Fig. 15 Trinkler-Korting Cold Combustion Chamber

Fig. 16 Hoflinger Cold Combustion Chamber



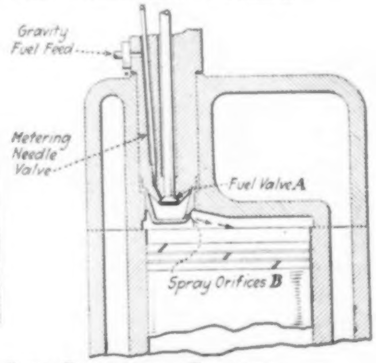




Fig. 17 Gernandt Cold Combustion Chamber

Fig. 18 Hvid-Brons Cold Combustion Chamber

projection and the walls changes the timing, while carbon causes a binding action. There is also a tendency toward reverse flow on the outstroke.

A modification of this engine designed by Trinkler and built by the German firm of Körting is shown in Fig. 15. Trinkler added a small piston *A* in a cylinder connected with the main cylinder at both ends. Just at the right time the piston *A* was moved out by a cam control so as to force air from the back end through the passage *B* to the spray nozzle. This little auxiliary piston *A* furnished the charge of supercompressed air for spraying the fuel, and it was timed like the old make-and-break ignition of the gas engine. The objection to it was that it tended to stick and stop the engine.

In Höflinger's proposed engine, Fig. 16, a small cuplike cylinder with a piston projects into the working cylinder. A passage for oil is connected below the piston and before the fuel is wanted it is deposited by the pump in that cup or bottom end of the small cylinder. Just when it is wanted a timing cam drives the piston down, compressing air on top of the fuel charge and expelling both through holes *A* in the side as an air spray. So far as is known, this engine has not been built, but it is very suggestive, especially when considered along with the very modern one reported from Detroit by Gernandt, Fig. 17, with special reference to use for automobiles. This has the Höflinger cup and fuel feed, but with a connection to a timing valve and to an auxiliary cylinder with a piston. The piston of Höflinger's cup is replaced by an independent piston *A* and separate timing valve *B*. Then at the right time the piston descends, the valve opens by a cam movement and the charge of air is supplied to the cup, spraying the oil into the cylinder.

Finally, the simplest of all in this class and the one form that has come into almost universal use for small stationary engines, and has practically no competition in its own field—farm units—is the Hvid, shown in Fig. 18. The Hvid retains the same fuel cup as the last two engines but with entirely different connections for fuel and provisions for supplying and timing the spraying air. The fuel is delivered into the cup by gravity through a mechanical valve *A*, so that after it is in the cup the latter is a closed chamber. The fuel is delivered into the cup long before injection, in fact, before compression begins. During compression air flows into the cup through three holes, *B*, which prevent the outflow of oil prematurely, provided the holes are small enough so as to be capillary. After compression is complete, the air in the cup has a lower pressure than the air in the cylinder, which differential is quickly equalized on the expansion stroke. As soon as the cup pressure exceeds the cylinder pressure, the cup air will spray the

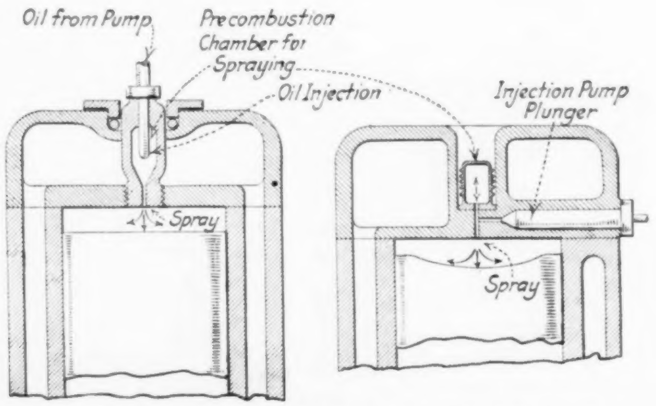



Fig. 19 First Steinbecker Cold Combustion Chamber
Fig. 20 Present Steinbecker Cold Combustion Chamber

oil into the cylinder. If the holes are too large, fuel will leak into the cylinder while the cup is being charged. If they are too many, the air escaping into the cylinder will come out of some without spraying oil out of the others. There is a limit to both the number and size of the holes and the net result is that the Hvid cup seems to be limited to small cylinders, but in a small cylinder where a small number of capillary holes will pass the right amount of oil it is thus far supreme. It is the simplest possible, automatic in timing because cylinder pressures control the timing of the spray, and the only objection is that the combustion is a little late or slow. This little engine may be said to represent the limit of commercial success for small engines with solid injection supplied by air without an air compressor.

Steinbecker has devised another spraying scheme which has been worked out experimentally. In the form shown in Fig. 19 a very small bulb-like chamber with a narrow neck is connected to the cylinder head. Through the top of this chamber a spray nozzle projects and delivers a jet or a coarse spray into the neck. At this time the air has already been compressed to and above the ignition temperature, so that as the oil escapes it immediately ignites, but not much can burn because not much of it can reach air in the narrow passage. What burns on the back face of the spray, according to Steinbecker, will raise the pressure in the bulb so as to produce an outflow of gases to respray finely what oil has been delivered to the neck and deposited on its walls. By the rise of pressure in the bulb, Steinbecker expected to really spray the main charge of oil.

Steinbecker has a recent engine, Fig. 20, in which the bulb chamber is retained, the neck passage is made extremely narrow so as to get a very high velocity through it, and injection pump delivery is led into the middle of the neck. It is timed so that oil enters near the end of the compression stroke while there is still some upward flow of air from the cylinder to carry it into the bulb chamber, which is unjacketed and hot, so as to produce ignition and combustion by explosion. The hot gases produced cause a reverse flow to the cylinder and spray the oil delivered later directly into the cylinder. This is Steinbecker's engine as it now stands, and as operated experimentally even in automobiles. The timing is directly by the pump, and should that pump force the oil in too soon, there would be an explosive shock. If the timing were wrong, the correct amount of oil would not enter the bulb and the spraying would fail also. It is probably quite sensitive to pump timing, as is not the case with some others, including the Hvid.

### The Divided Combustion Chamber as a Means of Preventing Detonating Shocks

One of the great difficulties with injection is to prevent the development of explosive shocks by too early, and loss of efficiency by too late, timing. Rapidly recurring detonations will wreck any machine in time. To direct the oil stream into the combustion chamber by a pump, without any other means of control of time and rate of combustion, is a method employed by Vickers in England, using a central pressure supply of oil admitted to spray valves by cam-timed oil valves. The equivalent was worked out by Junkers in Germany, using direct pump injection without timed oil valves, who succeeded in making it work in an aircraft engine, and to him is due the credit of first making a solid-injection heavy-oil engine that would fly in the air. In both cases, however—the German and the British—the fuel went directly into the cylinder and the production of detonating shocks was entirely a question of avoiding too early an injection—and earliness and lateness are a matter of a few degrees of crank angle. They must be extremely sensitive.

Here a different principle, intended to prevent detonating shocks and relieve the engine of the necessity for accurate timing, claims attention. In accordance with it the main combustion chamber is divided into two parts, one in the cylinder and the other removed—a divided combustion chamber. The air is compressed partly in the cylinder and partly in a connecting pocket, the major part in the former.

The first construction embodying this principle to be noted

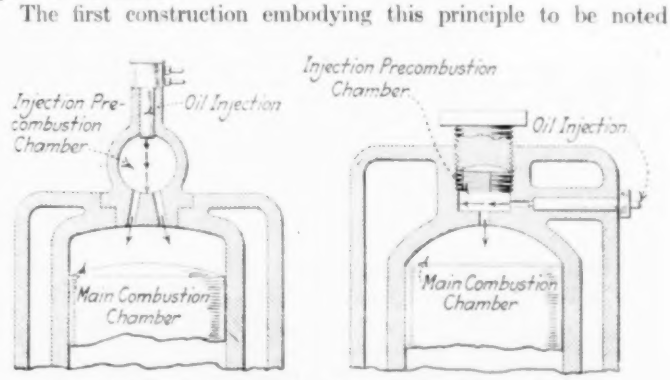



Fig. 21 Nydahl Divided Cold Combustion Chamber
Fig. 22 Nielsen Divided Cold Combustion Chamber

here is a Scandinavian one by Nydahl, shown in Fig. 21. He provided a spherical chamber connected to a cylinder by a series of holes and with an oil spray at the top. The piston stops at a point that leaves considerable air in the cylinder. There is a body of air in the cylinder and another body in the injection chamber at dead center. If the quantity of air in the injection chamber is small enough in comparison with that in the cylinder, then when the fuel is injected—the whole charge of fuel into the small amount of air—it cannot produce any explosive shock because so small an amount can burn. What, then, will happen to the rest of the fuel? It will change as it would in a gas producer where fuel reacts with less air than is required for combustion. Some of it will burn; the rest will gasify; possibly some will merely vaporize. In this divided-combustion-chamber construction the piston becomes the principal element of combustion timing, somewhat as in the Hvid engine because the main combustion is produced by the flow from injection chamber to cylinder. The divided combustion chamber is the principal element in preventing the explosive shocks, the piston movement controls the completion of combustion, and if the compression is high enough the whole structure can be jacketed.

Such a water-jacketed injection chamber, but of more or less cylindrical form, and embodying the divided combustion chamber and side injection of fuel, is shown in Fig. 22. This is a Danish

(Continued on page 686)

# Design and Construction of the 16-in. Disappearing Carriage from an Engineer's Standpoint

By MAJOR G. M. BARNES,[1] U.S.A., WASHINGTON, D. C.

I HAVE been asked to give you some of the details of the design and construction of the new 16-in. disappearing carriage for harbor defence. It was suggested that this Society would be interested in the construction of this large gun carriage from an engineering standpoint. I will therefore try to avoid any consideration of the carriage as a piece of ordnance and will describe it as a large machine, hoping that some of the problems which have been solved in the development of this large mount may be of interest and possibly may have some direct application to other engineering problems in which you are more directly interested.

This weapon is a 16-in. high-power gun, mounted on a disappearing carriage, especially designed for seacoast-defence purposes. The gun weighs 170 tons, while the carriage upon which it is mounted weighs an additional 670 tons. When emplaced in the seacoast fortification the gun and carriage will be in the rear of an embankment of sand and concrete of such thickness that the highest-power naval guns can not penetrate it.

As this embankment will reach nearly to the height of the gun when the latter is in the firing position, only the muzzle will be seen from the ocean side. When firing, the shock of discharge, which is equivalent to a force of over eight million pounds acting along the axis of the bore, drives the gun from the firing position into the loading position (Fig. 2), which is approximately 12 ft. below the position of the gun as shown in Fig. 1.

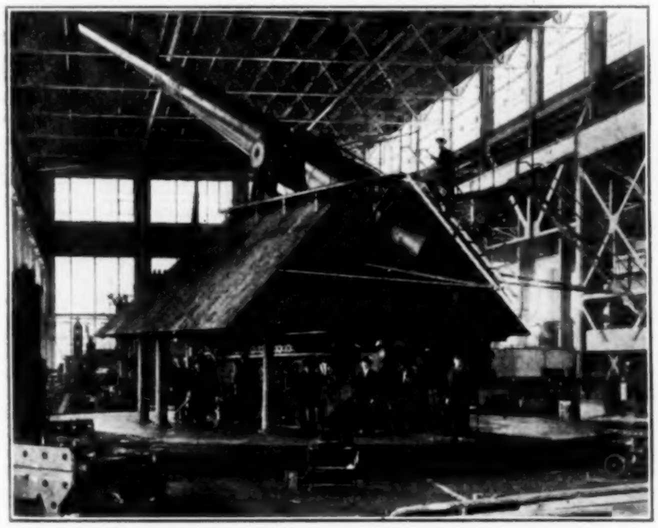


Fig. 1 16-in. Disappearing Carriage, Model of 1917

The gas pressure acts during the time the projectile is in the bore and for a short time thereafter. The force of explosion of the gun must be absorbed in the carriage so gradually and to such a nicety that there will be no shock or vibration to the carriage parts when the gun moves from one position to another. The gun pointer, who is stationed only 7 ft. to the left of the gun, must be able to keep his eye at the telescopic sight during firing and continue to direct the gun upon the target.

Although the gun and the carriage weigh approximately 840 tons, they can be easily turned in direction by the power of one man applied at the traversing handwheel. The armor-plate shed shown in the illustration protects the carriage and the gun crew from small shell fragments, concrete and débris which might fall about the gun if enemy shells should strike the parapet.

[1] Chief of Railway and Seacoast Carriage Section, Ordnance Department. Lecture delivered at a meeting of the Washington, D. C., Section of The American Society of Mechanical Engineers, March 31, 1921.

## Principal Parts of the Carriage

Fig. 3 shows diagrammatically the principal parts of the carriage. The gun is attached to the upper end of the gun lever by means of its trunnions. The gun levers are trunnioned near their centers to the top carriage, which is constrained to move up a plane inclined 1 deg. to the horizontal. The lower ends of the gun levers are connected to a crosshead, which is constrained to move vertically in guides.

A very heavy counterweight (315 tons) is attached to the crosshead. The function of this counterweight is to raise the gun from the loading or the recoiled position to the in-battery or firing position. The elevating arm, which is attached to the gun near

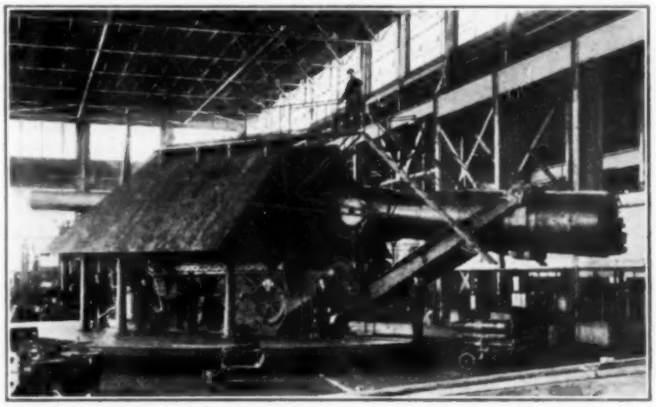


Fig. 2 16-in. Disappearing Carriage, Loading Position

its breech end, controls the elevation of the piece. The lower end of the elevation arm can be moved up or down. The slide, to which this end of the elevating arm is attached, is constrained by the rear bracket casting to move in the arc of a circle, the center of which is the position of the elevating trunnions in the loading position. The breech of the gun will therefore always return to the same position for loading, regardless of the angle of elevation at which the gun is fired.

When the gun is fired the shock of discharge is absorbed mainly in the following ways:

1 In raising the counterweight
2 In throttling oil through the varying orifices in the recoil cylinders, which are built into the top carriage
3 In moving the gun, gun lever and top carriage from the in-battery to the recoiled position.

## Forces Acting on the Members of the Carriage

In designing the carriage it is necessary to make a complete solution of the forces acting on the various members and to proportion the parts accordingly. The method used in determining these forces is given in detail in the book Stresses in Wire-Wound Guns and in Gun Carriages, by Col. L'H. Ruggles, Ordnance Department, published by John Wiley and Sons, Inc. Any one particularly interested in the mathematical solution of the forces acting on a carriage of this type will find a very complete solution in this book.

The maximum stresses occur in different members at different angles of elevation. It is therefore necessary to make calculations at various angles of elevation to determine the maximum stress which occurs in each member. Fig. 3 indicates the maximum stresses in the principal members of the 16-in. disappearing carriage when the gun is fired. The accelerations of the principal moving parts along the $x$ and $y$ axes are also given.

It will be noted that the force of the powder gases amounts to 8,700,000 lb. This force is reduced at the trunnions to $P =$

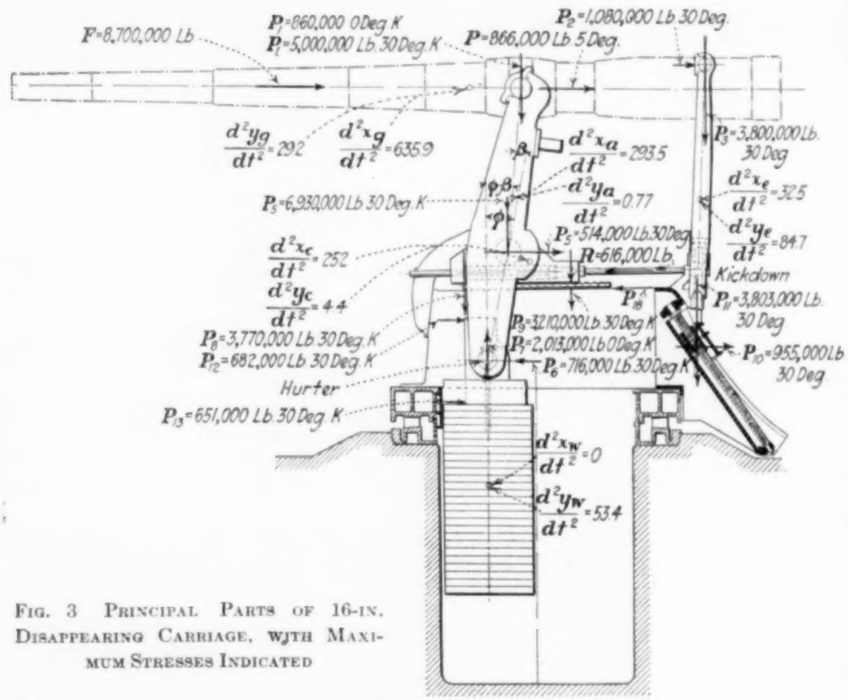



Fig. 3 Principal Parts of 16-in. Disappearing Carriage, with Maximum Stresses Indicated

866,000 and $P_1$ = 860,000 at 0 deg. elevation. At maximum elevation $P_1$, however, becomes 5,000,000 and the carriage parts must be designed to withstand this force. It is interesting to note that $P_7$ exceeds 2,000,000 lb. The value of the counterweight

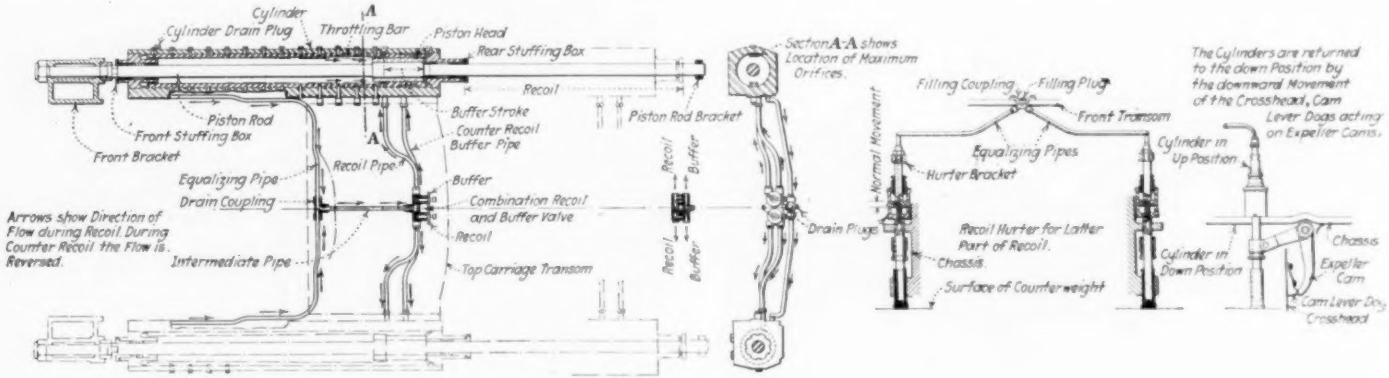



Fig. 4 Recoil Mechanism

in absorbing the energy of fire is therefore apparent. The piston-rod pull is 616,000 lb., and is assumed to be constant throughout the length of recoil.

It will be seen that the forces $P_2$ and $P_3$ acting on the upper end of elevating arm are very large. These forces have been computed on the assumption that this arm is rigid. In order to reduce the force on the elevating arm, it has been made elastic; that is, a second recoil mechanism has been introduced. This recoil mechanism allows the arm to shorten when a large stress is brought upon it. As soon as the stress is relieved, the arm returns to its original length. The introduction of the elastic arm slightly increases the stresses in the gun levers and other members, which must be computed on this basis. The arm still fulfills its function of keeping the gun at the proper elevation.

### The Recoil Mechanism

A part of the energy of fire is absorbed in the recoil mechanism. This mechanism is simple and consists of two cylinders located in the top carriage. The piston heads and pistons are stationary, while the recoil cylinders move back and forth. The cylinders are formed by two forged-steel liners slipped into the longitudinal holes in the top carriage. Two bars, called throttling bars, are bolted to the interior of each cylinder. Two corresponding notches are cut in the piston head. The upper surface of the throttling bars is a curved surface and so proportioned that the pressure in the cylinder is constant over the length of recoil.

The arrows indicate the direction of the flow of oil during recoil. The piston rod and head remain stationary while the top carriage moves to the rear. The length of recoil can be controlled by means of the throttling valve, which when open allows the oil in the recoil cylinder to pass to the low-pressure side without throttling past the throttling bars. When the gun goes from the out-of-battery to the in-battery position, the top carriage moves forward and the direction of the flow of oil is reversed. Just before the gun reaches the in-battery position the counter-recoil buffer acts. As the male buffer, which is part of the piston head, enters the rear end of the cylinder, the oil is gradually forced out. The remaining energy in the gun and counter weight is thus gradually absorbed and the gun comes to rest without shock. This action can also be controlled by means of the buffer valve, which when open allows the oil to escape to the recoil cylinder.

There is also another device used to help absorb the final energy at the end of recoil and counter recoil. This system, called the "hurter" system, is shown below the cylinders (Fig. 4). Just before the counterweight reaches its upper position it strikes the lower end of the hurter cylinders. The pistons of the hurter cylinders are rigidly attached to the carriage and are stationary while the cylinders are movable. Oil in the lower part of these cylinders, which is the high-pressure side, throttles past the recoil stem, up through its center and out into

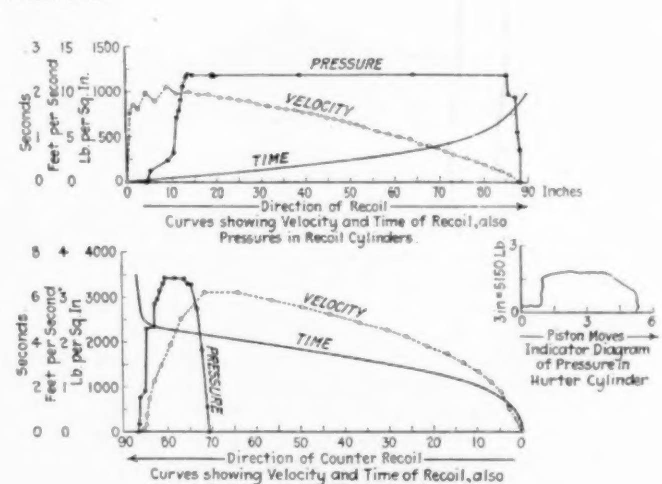



Fig. 5 Pressures in the Recoil System

the low-pressure side. Also before the counterweight reaches its lower position the hurter cylinders are forced down by the expeller cam and the reverse action takes place. The recoil stems are

(*Continued on page 674*)

# Control of Corrosion in Iron and Steel Pipe

## Corrosion of Iron or Steel in General—Protection of Pipe Against Exterior Corrosion—Internal Corrosion of Water Pipe and Its Prevention

By F. N. SPELLER,[1] PITTSBURGH, PA.

WHILE there is a vast difference in the amount of corrosion of iron and steel under different conditons, and it has been proved that the relative corrosion of these metals also varies decidedly with surrounding conditions, there are certain fundamental causes which underly all cases of corrosion which should be understood by all who are interested in this problem in any of its phases.[2]

Every metal when placed in water is subjected to a fixed tendency to go into solution. This is wholly a matter of electrochemical activity and varies to a definite extent with each metal. Thus the initial reaction in the process of corrosion is analogous to solution in acid, pure water being in effect a very weak acid. The acidity of the water depends on the concentration of the hydrogen ions, which determines the initial speed of attack. As in all electrochemical reactions, however, the initial speed of solution soon slows down as the numerous little electrochemical couples which form over the surface of the metal become "polarized" due to the accumulation of hydrogen on their cathodic surfaces, ultimately stopping the solution of the metal. In the case of iron a small amount of the metal (less than 10 p.p.m.) is dissolved as ferrous hydrate, which also has a decided retarding action on the solution of the metal. This, the first stage of the corrosion of iron, while essential, is not a serious matter if the reaction between water and iron can be stopped at this point. As a matter of fact this reaction cannot proceed unless in some way or other the hydrogen film protecting the metal is removed. This is usually brought about by means of something in the nature of a depolarizer, generally free oxygen, which also combines with ferrous hydrate forming insoluble ferric hydrate, commonly known as rust.

This, the second stage of corrosion, is thus caused by the oxidation of hydrogen and ferrous hydrate in solution by the free oxygen of the atmosphere. Oxygen is soluble in water at normal temperature to the extent of about ten parts by weight per million (7 cc. per liter), and as water readily absorbs more oxygen when this element is used up, as in rusting under atmospheric conditions, it will be seen that under such conditions the reaction will continue until the metal has been destroyed; or the reaction may be brought to a stop at any time through exhaustion of the supply of available oxygen.

Water and oil lines suffer mainly from outside corrosion due to soil conditions, which resembles more nearly corrosion under water than atmospheric corrosion. Underground corrosion may be accelerated by the presence of certain salts or acids in the soil, and by the more ready access of free oxygen either by direct circulation of air or by means of underground waters which have become charged with oxygen and carbonic acid. The corrosive action is greatly increased by a rise in temperature and velocity of water within certain limits and by contact of the metal with any materials which tend to intensify galvanic action, such as cinder or certain kinds of mixed trench fill, or even the heavy mill scale formed in hot finishing of the pipe, which has a strong tendency where firmly attached to localize corrosion and cause pitting. Rust once formed on the surface also acts as an accelerator to a somewhat lesser extent.

From this brief outline of the main factors which tend to influence corrosion it will be seen how important it is to keep all parts of the pipe from contact with wet soil or water through the use of protective coatings of substantial thickness properly applied.

The influence of composition of the metal under most conditions does not seem to have much effect in itself, all other things being equal. Wrought-iron, bessemer-steel, and basic open-hearth steel pipe have been in service thirty years or more, the records of such lines showing failures in some places and practically no corrosion in other places, depending on soil conditions, drainage, and other external factors. So far as the metal itself is concerned the factor of prime importance as affecting initial corrosion seems to be the surface finish, particularly the mill scale, which is decidedly electronegative to iron and therefore is a more or less powerful accelerator of corrosion.

### Protection Against Exterior Corrosion

From the foregoing it will be understood that the main object of protective coatings is to exclude water from contact with the metal. Such coatings as are available at present are by their very nature easily damaged and thus rendered practically useless if subject to abrasion after being applied. No coating has yet been found which has any chance of protecting such a material as oil-well casing. Most of what follows is therefore applicable mainly to line pipe or water pipe subjected to underground corrosion.

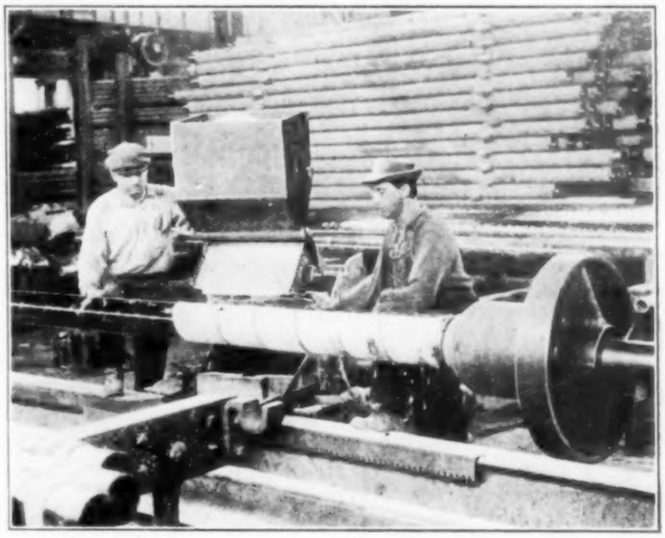


Fig. 1 Machine for Wrapping Pipe Spirally with Fabric after Application of Hot Bituminous Coating

Before any coating is applied in the field all loose rust or scale should be removed and a thin priming coat applied to the clean dry surface after the line is put together and ready to be ditched. When a priming coat is applied at the place of manufacture, it is important that the surface should be cleaned and freshened up before any further protective coating is applied in the field. The subsequent protection needed depends on conditions which should be determined by a careful survey of the nature of the soil and drainage of the territory in which the line is to be laid. In well-drained sand or clay soils a second coat of some reputable pipe compound may be all that is necessary or perhaps one coat may be sufficient, but in wet marshy places, especially where the ground water is corrosive, a much more substantial waterproofing will be necessary. Wherever the ditch can be drained economically, it will of course be of considerable advantage to do so.

The function of the priming coat is principally to afford a strong bond between the thicker protective coating and the metal, and is essential where the subsequent coat is applied hot to the relatively cold metal. The priming coat may consist of coal tar or a pure asphalt dissolved in naphtha or benzol to a thin cosistency. It is of little protective value in itself as is true of paints in general underground. To be of any practical value where underground corrosion is known to occur, a non-porous coating of substantial thickness

[1] Metallurgical Engineer, National Tube Company. Mem. Am.Soc.M.E. Presented at a meeting of the Ontario Section of The American Society of Mechanical Engineers, Toronto, February 2, 1921. Slightly abridged.

[2] Those who want to go into further details of the mechanism of corrosion may consult a paper on Preservation of Hot-Water Pipe, by Speller and Knowland, Trans. A. S. H. & V. Engrs., vol. 24 (1918), p. 217.

is required. The coatings which have given the best service may be classified as follows:

1 Melted bituminous mixtures which can be safely heated to 350–400 deg. fahr. with a melting point of about 150 deg. fahr. may be applied in the field with suitable brushes operated by hand or mechanically. Sometimes a coating of this class is poured over the pipe, the surplus being caught in a strip of canvas about 30 in. wide held by two men, by which means the coating can be worked evenly over the underside of the pipe. In this way with some care and practice a coating of from $^1/_{16}$ to $^1/_4$ in. thick may be applied without much variation in thickness.

The well-known dips applied at the works by manufacturers come under this heading. Most pipe has to stand a wide range of temperature fluctuation enroute to destination, often as much as 100 deg. fahr. If the temperature drops below the brittle point the coating is liable to crack off, and if the solar heat absorbed raises the temperature of the coating above the melting point the mixture runs, in addition to which there is always a certain amount of damage due to abrasion in handling, all of which necessitates careful inspection and attention to repairs. Coal-tar pitch when properly refined makes one of the best preservative coatings, but unfortunately the range between the brittle and melting points of this material rarely exceeds 45 deg. fahr., so that an asphalt blend must be used in most cases where the pipe has to be shipped any distance after coating. The absorption of solar heat may be limited considerably by dusting the surface of the pipe with portland cement or fine white sand. A coating of whitewash applied over the sanded surface has been tried and was found to keep the temperature of the coating down to atmospheric temperature under the July sun.

2 Under some conditions the coating above described may be reinforced with advantage by a strip of fabric 6 or 8 in. wide wound spirally around the pipe while the coating is hot. This is easily done at the mill after the pipe has received the dip coat, by means of a machine designed for the purpose (Fig. 1). The fabric should be dried in vacuum and saturated by passing through a small tank of the asphaltic mixture as it passes on to the pipe. With pipe 12 in. and smaller a saturated fabric in rolls of suitable size would be convenient for this purpose in the field, such as a large-size electric tape, or the fabric may be saturated after application by a final coat of thin consistency. This method of protection has been used for some years and has become standard with one American manufacturer for bell-and-spigot steel water pipe, having been found to give good service.

3 Where the ditch is wet most of the time, especially where stray electric currents are likely to occur in the vicinity of the pipe, provision should be made to keep these stray currents off the pipe by the use of insulated joints or other means.[1] The pipe should then be boxed in as indicated in Fig. 2 after being cleaned and having received the usual priming coat. The pipe is supported underneath every 10 ft. or so on some non-porous insulating material such as a piece of hard-burned sewer pipe or heavy glass about $^3/_4$ in. thick. An asphaltic compound such as Parolite or some similar mixture with a melting point of about 150 deg. fahr. which has been heated so as to run readily is poured in between the pipe and the box on one side. Particular care should be taken that the asphalt passes underneath the pipe without leaving air pockets, which would of course leave an opening for water to penetrate the coating. This coating has been found to be very effective both against corrosion and electrolysis when applied uniformly and not less than $^3/_4$ in. thick.

4 Where corrosive conditions are severe as in marshy places where the water is brackish or acid, a covering of concrete has proved to give the best protection. A mortar of 3 parts sand to 1 of portland cement thoroughly mixed together should be poured between the pipe and the box as in the case of the bituminous coating (see Fig. 2). The pipe should be centered in the box and supported on non-porous material at suitable intervals so that the coating will not be less than 2 in. in thickness for 8- or 12-in. line pipe. The same precautions should be taken as under (3) to avoid air pockets, with careful inspection to avoid leaving any uncoated places. The sideboards may be removed and reused. If this is done a coating of asphalt should be applied to the sides of the concrete before filling in the ditch.

Oil lines protected in this way in brackish water have been free from corrosion for 25 years near the New Jersey coast. Precautions must be taken to guard against or repair cracking from expansion or contraction, or settlement.

Concrete coatings are not proof against electrolysis.

### Internal Corrosion of Water Pipe

The corrosion to which iron or steel pipes are subjected from contact with the water on the inside is not so serious as external corrosion; on the other hand, it is somewhat more difficult to protect against.

The principal factors which determine the rate and character of internal corrosion and pitting are:

1 Composition and finish of the metal

2 Composition, temperature and rate of flow of the water.

In the case of corrosion under water, the composition of the metal does not seem to have any marked influence on the character or amount of corrosion. Internal corrosion of cold-water pipes is usually so slow as to be negligible, although in some localities this is not the case. However, the rate of corrosion is usually so slow as to be difficult to determine with cold water, but when the water is heated under pressure the corrosive action is so much accelerated as to make it practicable to compare different materials in the same line and get trustworthy results in a year or two.

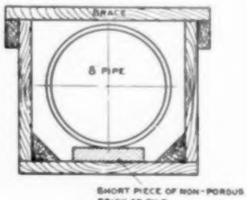



Fig. 2 Section of Wooden Form Used for Application of Asphalt or Concrete Coating

It has often been noticed that internal pitting is much deeper near mill scale where the scale is thick and firmly attached. The reason for this is undoubtedly due to the electronegative character of the scale with respect to iron. Old rust acts somewhat in the same way, but is much less harmful. When the mill scale and rust are removed the tendency to pitting is greatly reduced provided the metal itself is fairly homogeneous and free from strains. It has been clearly demonstrated experimentally that surface finish is much more of a controlling factor in corrosion than any variation in composition of the metal in itself, which is likely to occur, the explanation of this fact being that the external difference of potential due to mill scale and other extraneous matter is much greater than that due to segregation or other irregularities in the metal.

There is a wide difference in the rate of corrosion with different domestic waters at normal temperature. Take, for example, Great Lakes water in comparison with the water supply of most of the New England cities and New York City. An interesting and useful example of corrosion greatly accelerated due to the magnesium salts in the water, is that of the 30-in. steel main to the Coolgardie mining district, Western Australia.[1] A few years after this pipe line was put into use serious corrosion was found both inside and outside. The deepest inside pitting was within a few inches of the lockbar seam where the mill scale had not been broken off in bending the plate. The engineers who investigated this case are of the opinion that had this scale been removed before coating, pitting would not have occurred or would have been greatly limited. The cause of corrosion and means of prevention were investigated by Sir Alexander Binnie, Sons & Deacon, Sir William Ramsay, and Mr. Otto Hehner, who in their joint report, Sept. 30, 1909, recommended that three grains of lime per gallon be added to the water and that the water be deaerated and that precautions be taken to prevent reabsorption of air. The lime treatment was tried first but resulted in a considerable increase in thickness of scale on the interior walls of the pipe. Before the lime treatment was tried a heavy coating of rust and scale had formed in places. The effect of the lime treatment on corrosion of this pipe according to the above report was rather inconclusive and disappointing. Deaerating was then tried. The reports after two years' service

(*Continued on page 697*)

[1] For practical and up-to-date information on this subject, see forthcoming report of the American Committee on Electrolysis which will soon appear under the auspices of the American Institute of Electrical Engineers.

[1] O'Brien and Parr, Proc.Inst.C.E., vol. ccv. part 1, 1917–1918.

# Steam Superheaters: Their Design, Construction, Application and Use

## Fundamentals of Design and Materials Used—Characteristics and Details of Locomotive, Marine and Stationary Superheaters—Operating Conditions Where Reciprocating or Rotating Prime Movers Use Superheated Steam—Results Obtained by Using Superheated Steam

By H. B. OATLEY,[1] NEW YORK, N. Y.

SINCE 1700, when the noted French physicist, Denis Papin, inserted a heated mass of iron in a piston, so that the steam moving the piston might be kept freer from moisture, the advantages of superheated steam, the difficulties of properly designing apparatus for generating it, and the necessity for having prime movers so fitted as to use it effectively, have been known and, as time passed, have been more keenly appreciated by engineers throughout the world.

The present paper will be confined to four phases of the question, namely:

*a* Fundamentals of design and materials used
*b* Characteristics and details of locomotive, marine and stationary superheaters
*c* Operating conditions where reciprocating or rotating prime movers use superheated steam
*d* Results obtained by using superheated steam.

### Design and Materials

Only the tubular form of superheater, and its use as an integrally-built live-gas or waste-gas superheater will be herein discussed.

Important factors in superheater design may be considered under the headings of efficiency, durability, accessibility and safety. A design to be of merit should have a high rating in these four fundamentals.

*Efficiency* may have three interpretations: efficiency in design, efficiency in operation, and efficiency in return on the investment.

Efficiency in design may be measured in terms of superheater bulk and weight, and by the draft retardation produced by its inter-

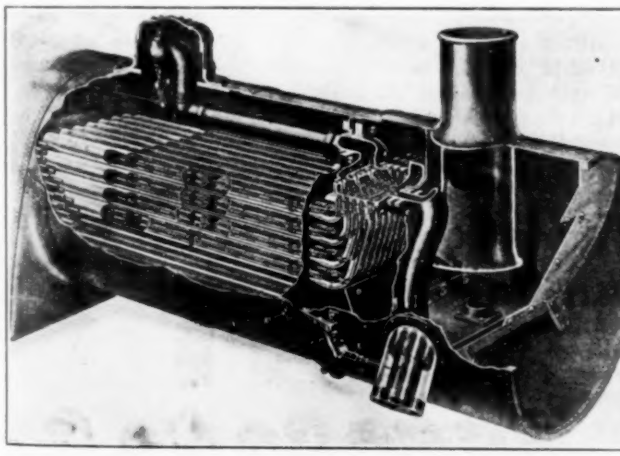


Fig. 1 American Standard Locomotive Superheater, Type "A" Equipment

position in the path of the products of combustion. It is generally true that a superheater of minimum bulk will have a minimum weight and naturally offer a minimum retardation to gases. It also follows that superheaters located in relatively high gas-temperature zones have greater heat-transmitting efficiency; hence, are smaller and more advantageously used. In many cases waste-gas superheaters of not over 50 deg. fahr. capacity have double the weight and bulk of 200-deg. fahr. superheaters of the live-gas type. In the foregoing consideration of elements of design, equal capacities of the superheater should be made the basis of comparison.

Efficiency in operation is affected by the sustained cleanliness of both the gas-touched and steam-touched surfaces, by accessibility for inspection, tightening and repair of the superheater itself, or by the ease with which conditions existing in the vicinity and affecting the performance of the superheater may be corrected.

The character of the outer surface of the superheater pipes, whether smooth or corrugated, controls the ease and thoroughness with which it may be cleaned. It also limits the ability of the soot blower to thoroughly cleanse the superheater from soot and dirt. The predominant use of the smooth surface indicates a general acknowledgment by superheater designers and users of the heavy

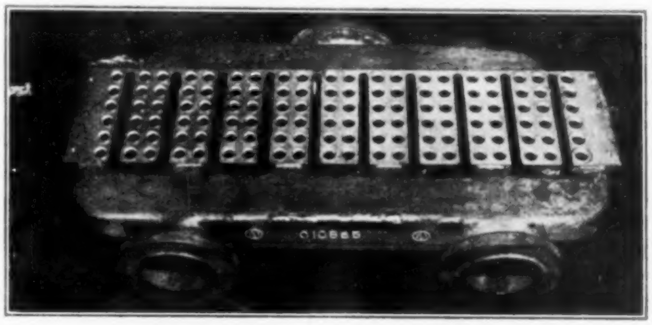


Fig. 2 Preferred Form of Top Header

heat losses resulting from soot-coated superheaters, and the difficulties in cleaning rough surfaces. The importance of the heat losses possible due to soot will be better appreciated when it is realized that it requires five inches of fine asbestos to equal the heat-insulating capacity of one inch of soot.[1] The time required to blow soot from the superheating surface should be as brief as possible, in order to conserve steam.

Efficiency in return on the investment is affected by first cost of the superheater, installation expense and maintenance charges compared with the financial gain obtained. Generally speaking, fuel economy is first considered among the advantages of superheating, although in many cases, particularly in railway and marine service, the results of large water economy aggregate a considerable item. Reduced boiler maintenance, because of the smaller quantity of fuel burned, and water evaporated, per horsepower-hour frequently appears as a credit due the superheater.

*Durability* is measured by the life of the superheater parts, and by the period elapsing between repair periods. This feature is affected by service conditions, and by the position of the superheater with respect to the path of the gases. In superheaters located where soot accumulation is rapid and where moisture may reach it, the soot will produce greater deterioration than where the superheater elements are subjected to live gases. This to some extent may explain the attempt to protect, by cast or malleable iron, steel unit pipes of waste-gas superheaters. The deposit of soot is naturally less where gas velocities are high, and explains the preference of the majority of designers for live-gas superheaters, and for the high gas velocities that are obtainable with such designs.

*Accessibility* should embrace "getatability," not only of the superheater but of adjacent parts of the boiler and other details. A minimum number of steam joints in the superheater, and their location at a point where inspection may be made without shutting

[1] Chief Engineer, Locomotive Superheater Co. Mem. Am.Soc.M.E.

Condensed from a paper presented at a meeting of the Eastern New York Section of The American Society of Mechanical Engineers, Schenectady, N. Y., January 13, 1921.

[1] *Paper Industry*, November 1920, p. 1187.

down the boiler, or involving excessive labor and trouble in making such inspection, are to be considered under this head.

*Safety* rarely becomes a problem in superheater design, inasmuch as the size of superheater parts is small in comparison with boiler drums and also because the stored energy in the entire superheater is relatively small. Furthermore, the factor of safety in both units and headers, due to the consideration of durability, and the small sizes of parts, is relatively high. In case of failure of a unit, damage to property is negligible and injury to the operating personnel practically unknown. A representative of one of the largest insurance companies recently made the statement before a board of boiler inspectors that his company, and he believed that other companies, had not received a single claim in connection with a superheater failure.

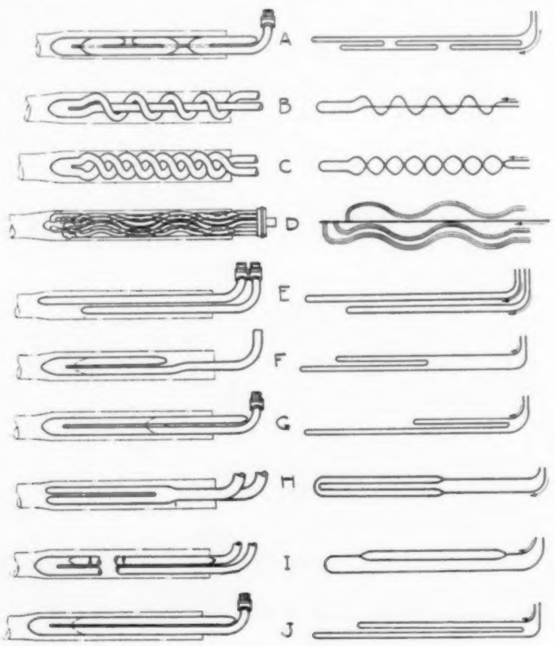



FIG. 3 TYPES OF SUPERHEATER UNITS

### CHARACTERISTICS AND DETAILS

It may not be realized that the locomotive superheaters in use in this country alone have an aggregate horse power ofover 60,000,000. All of these superheaters have tubular structure, and are of the bare fire-tube live-gas type. What is true in the United States as to type and structure of superheater, is true in other countries of the world where steam locomotives are in use.

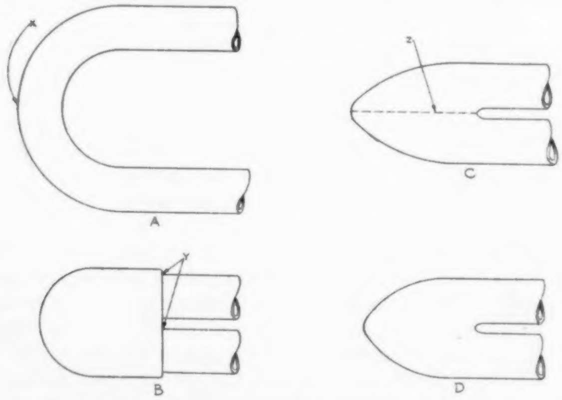



FIG. 4 METHODS OF CONNECTING TWO PARALLEL PORTIONS OF A SUPERHEATER UNIT

The limitations imposed in the design of a superheater for a locomotive boiler are, in the author's opinion, more severe than for any other use. Space is restricted, weight conditions important and the requirements for high degrees of superheat very pronounced. The compactness of the boiler provides severe operating conditions for the superheater, because of the quality of the steam delivered to it. Steam velocities existing within the superheater units, gas velocities passing over the outer surface of the units and the necessity for strong and rugged structure to withstand the severe vibratory conditions encountered while the locomotive is running, require great care in the design and construction of the equipment.

The superheaters installed in more than half of the steam locomotives in this country weigh from 3.0 to 4.0 lb. per maximum cylinder horsepower of the engine. These figures are interesting, particularly in comparison with the running-order weight of engine per maximum cylinder horsepower, which, on the modern locomotive, ranges between 115 lb. and 160 lb. The figures in Table 1 show these ratios for the United States Railway Administration standard engines built during the war.

TABLE 1 WEIGHTS OF SUPERHEATER AND ENGINE PER MAXIMUM CYLINDER HORSEPOWER OF U.S.R.A. STANDARD ENGINES BUILT DURING THE WAR

| Type of engine | *A* Weight of superheater, lb. | *B* Max. cyl. hp. | $\frac{A}{B}$ | *C* Weight of engine only, lb. | $\frac{C}{B}$ |
|---|---|---|---|---|---|
| 060-A | 4326 | 1397 | 3.10 | 165000 | 118.2 |
| 080-A | 6475 | 1822 | 3.56 | 214000 | 117.5 |
| 282-A Light | 8432 | 2252 | 3.75 | 290800 | 129.2 |
| 282-B Heavy | 9451 | 2308 | 4.09 | 325000 | 141.0 |
| 2102-A Light | 10016 | 2428 | 4.13 | 352000 | 145.2 |
| 2102-B Heavy | 11023 | 2850 | 3.87 | 380000 | 133.4 |
| 462-A Light | 7669 | 2082 | 3.68 | 277000 | 133.0 |
| 462-B Heavy | 8432 | 2428 | 3.47 | 306000 | 126.0 |
| 482-A Light | 8931 | 2428 | 3.68 | 327000 | 134.8 |
| 482-B Heavy | 10016 | 2610 | 3.84 | 352000 | 135.0 |
| 2662-B | 11386 | 2810 | 4.05 | 448000 | 159.7 |
| 2882-B | 13554 | 3720 | 3.64 | 531000 | 142.8 |
| | | Average = | 3.74 | | 124.6 |

The steam velocity in units of locomotive superheaters frequently is in excess of 12,000 ft. per min. This may be startling to many power-plant engineers who consider 6000 to 8000 ft. per minute as the upper limit of steam velocities in pipe lines.

Gas velocities through the flues of locomotive boilers, as in stationary power plants, vary through a wide range, and it is not unusual to find velocities of 8500 ft. per min., or more than 90 m.p.h., when locomotives are working to their capacity.

Fig. 1 shows the American standard locomotive superheater termed the type "A" equipment. Its general characteristics are believed to be well known and the description will be centered on the question of headers and units.

Fig. 2 shows the preferred form of top header, termed the "modified through-bolt" design, which is fitted in nearly one-half of the superheater locomotives in this country. This header is made of high-grade cast iron, is rather intricate in coring and good foundry practice is required in order that a satisfactory header may be obtained. Alternate cross-passages carry saturated steam and superheated steam. Expansion is provided, as well be noted from the coring which separates adjacent fingers, without setting up excessive stress in the header. This construction at the same time reduces to a practical minimum the amount of wall surface subjected to different qualities of steam.

FIG. 5 STEPS IN THE FORGING OF SUPERHEATER RETURN BENDS

There have been numerous forms of header, in which cast-steel

and steel-plate construction have been used. Experience has demonstrated, however, that there is no necessity for using cast steel.

Units in locomotive superheaters are universally of cold-drawn seamless steel tubing and range from $1^3/_8$ in. to $1^5/_8$ in. outside diameter, with the $1^1/_2$-in. size as the most generally used size.

Units designed for use in fire tubes have undergone a most interesting development. Fig. 3 illustrates a few forms, all applicable to a fire-tube superheater, and some possessing features applying equally to a water-tube boiler installation.

In summing up the question of superheater unit, it is considered that unit *J*, which is really a world-standard form, represents the highest average of any thus far developed, particularly when considered on the basis of—

*a* Efficiency in the abstraction of heat from the gases
*b* Thorough mixing and *uniform* superheating of the steam
*c* Better equalization in the area of gas passage and more constant gas velocity
*d* Maximum superheating surface
*e* Minimum resistance to flow of gases when (*c*) and (*d*) are considered
*f* Less opportunity for deposit of soot and cinders by maintaining relatively high gas velocity through length of flue
*g* Cost.

Units *H* and *I* are forms not thus far used, but experiment has demonstrated that they will meet, from an efficiency standpoint, all of the advantageous features of the standard unit *J* and from a practical operating standpoint would not differ appreciably from the standard unit. They would be more expensive to manufacture, and under present conditions are, therefore, not generally preferred.

In the design and installation of units two important features are (*a*) return bends and (*b*) the jointing of units to the headers. Fig. 4 represents the development in connecting two parallel portions of a superheater unit.

Sketch *A* is the simplest form and is merely a pipe bent into a "U," or hairpin, form. Diameter of tube and distance between the two pipes have naturally minimum limits if distortion in the bent portion of the pipe at *X* is to be avoided. For fire-tube superheaters, where a close spacing is essential, bending of the pipe in this way is obviously prevented.

Form *B* shows two pipes fitted to a return bend. The return bend as used is almost always of cast steel, and the pipes are threaded into it. In designs where expansion stresses are excessive, it is necessary to acetylene or electric weld the joint *Y* between the return bend and the pipe, in order to insure permanent steam-tightness.

Increasing demands in capacity, particularly for locomotive and marine installations, require a minimum of obstruction in the flue and, for a number of years, pipes have been joined by forming their ends, and welding the two pipes together as shown at *C*, Fig. 4, the welded joint being at the point *Z*. The extremely severe service conditions of a superheater have demonstrated that the durability of electric or acetylene welds is not sufficient to insure requisite life and freedom from possible steam leakage. Long experiment and persistent efforts to develop practically a perfect bend resulted in the form now in world-wide use, and termed the "forged" return bend. In appearance it is as shown in sketch *D*. Particular points of advantage are uniformity in the character of the metal, freedom from any roughness or obstruction, either within or without the return bend, and a strength which is never less than that of the pipes of the unit from which the return bend is made.

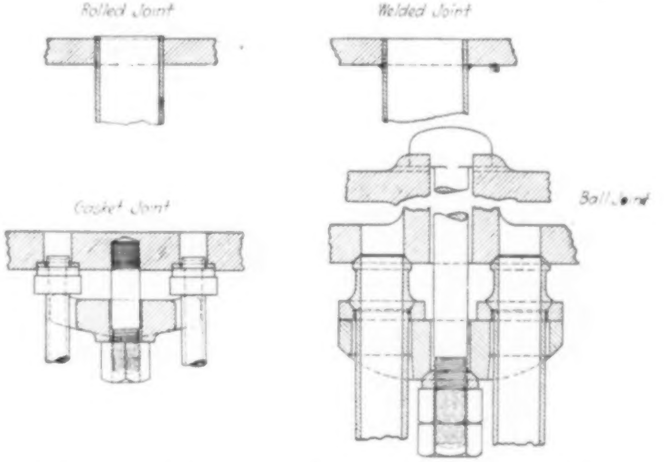



Fig. 6 Methods of Connecting Superheater Units to the Headers

Fig. 5 shows the steps in the process of forging this return bend. It is proper to emphasize that it is made *from the pipe* without the addition of any other material. The finished unit therefore becomes practically a continuous pipe without other than forged welds.

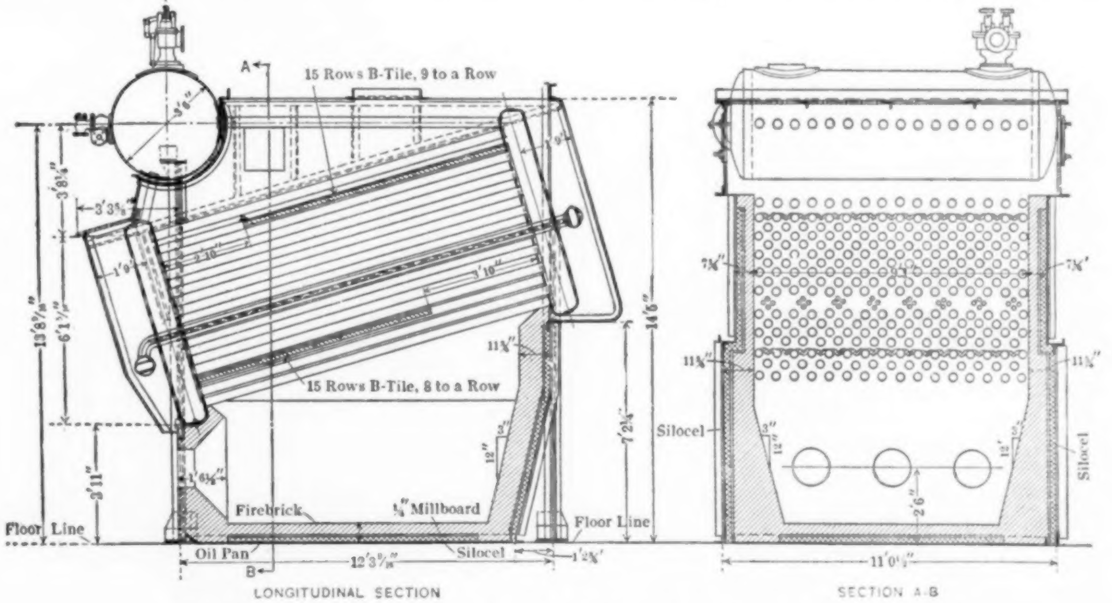



Fig. 7 Setting for Heine Boiler Built for the Emergency Fleet Corporation

The jointing, or connection, of superheater units to the headers, or collector castings, is another detail which has passed through numerous stages of development. Methods of connecting these two superheater parts may be classified as permanent and detachable, and are shown in Fig. 6. The term "permanent" as here used covers joints which are welded, or are made by rolling the pipe in the header, either method requiring considerable work and time for removal.

Where pipes are welded to the header, actual breaking of metal

is necessary in order to remove a unit. Where pipes are rolled into a header, in a manner similar to the setting of a tube in a boiler, it is necessary to remove a handhole plate, or a plug, and then to crimp the expanded end of the unit pipe and drive it out of the header. It is, of course, possible to cut off the unit outside of the header, and to remove the cut-off portion separately. This is perhaps better practice, as it makes available, for later attaching the unit to the header, material which has not been stressed and fatigued by previous rolling and expanding. Obviously, to cut

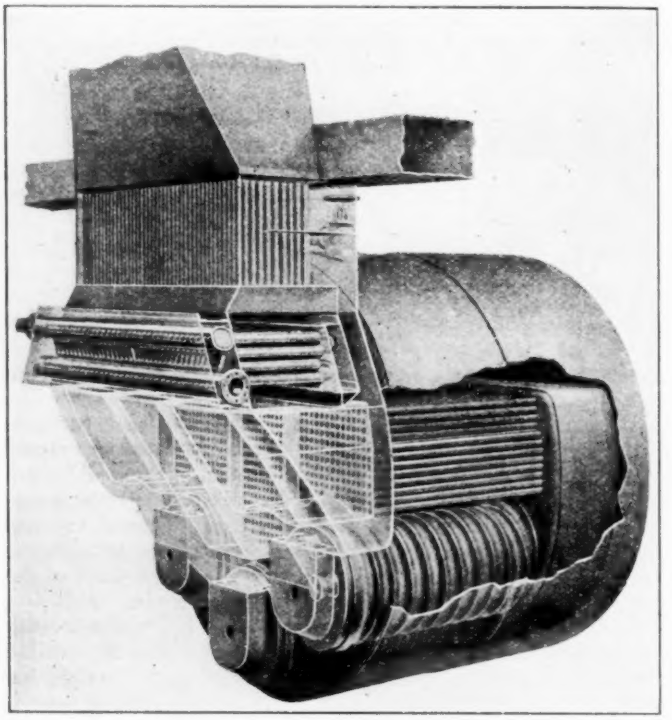


Fig. 8 Foster Superheater in Scotch Marine Boiler Utilizing Waste Heat

off the end of a unit, applicable to fire-tube boilers, makes necessary welding on a short piece of pipe, or rebending the unit, in order that it may reach the header, and at the same time occupy its proper position in the boiler tube. Either method involves considerable time and expense.

Disconnectable, or detachable, unit ends have been in almost universal use for locomotive and marine superheaters, and to a considerable extent in stationary practice. The advantages of disconnectable units are obvious and recognized fully in all lines of superheater use.

Fig. 6 shows both the gasket joint and the ball joint, and quite well illustrates the forms used throughout the world.

The gasket joint is to be preferred where the smaller diameter and more flexible superheater pipes are used. With small pipes the joint is easily drawn up normal to the seat and, because of the flexibility of the pipe, expansion and vibration cannot produce leakage.

In the locomotive field where unit pipes are of larger diameter and consequently more rigid, it has been found of decided practical advantage to use a metal-to-metal spherical joint. This form has been developed in the United States and its adoption has followed in a number of other countries.

### Some Considerations in Marine Practice

In marine practice fire- and water-tube boilers are met with. The former have, for years, been used almost exclusively in merchant ships, while the latter, for a decade or more, have been practically a standard in naval construction. During, and since, the war, water-tube boilers have had greater application to passenger and cargo vessels.

Fig. 7 shows a Heine boiler as fitted in a number of war-built American vessels. The unit pipes are parallel to the water tubes, running through both water legs, and being attached, front and back, to the headers by rolled joints. The use of this type of equipment has thus far been confined to American vessels built within the past four years.

Fig. 8 illustrates the Power Specialty Company's waste-gas superheater, which was applied to both Scotch fire-tube and water-tube boilers fitted in some vessels built by the Emergency Fleet Corporation. The units in this design are of the covered type with extended surface. The covering is of cast or malleable iron slipped over the steel superheating tube. The units are attached to the header, as well as to the return bend, by rolled joints with handholes and covering plates opposite the pipe opening.

Fig. 9 shows the Locomotive Superheater Company's type M apparatus, the units being of the bare-tube type with forged return bends, and are connected to the headers by the recess gasket joint previously referred to. With this method of joining no handholes or handhole covers are required.

Fig. 10 is a picture of a complete superheater withdrawn from a Scotch boiler. The headers, to which the units are attached, are made of either high-grade cast iron, cast steel or forged steel, as may be desired, and as may be deemed acceptable by the classification societies in the countries in which the ship is to be built. Attention is invited to the chief difference between the type M marine superheater, and the type A locomotive superheater. In the marine design, pipes of from $^5/_8$ in. to 1 in. outside diameter are used, and only one loop of the unit occupies a flue. In the locomotive type two loops of a unit occupy the same flue. In the marine type there may be from two to six loops in as many flues, depending on the proportions of the boiler and the degree of superheat specified.

In type M installations no change is usually made in the diameter

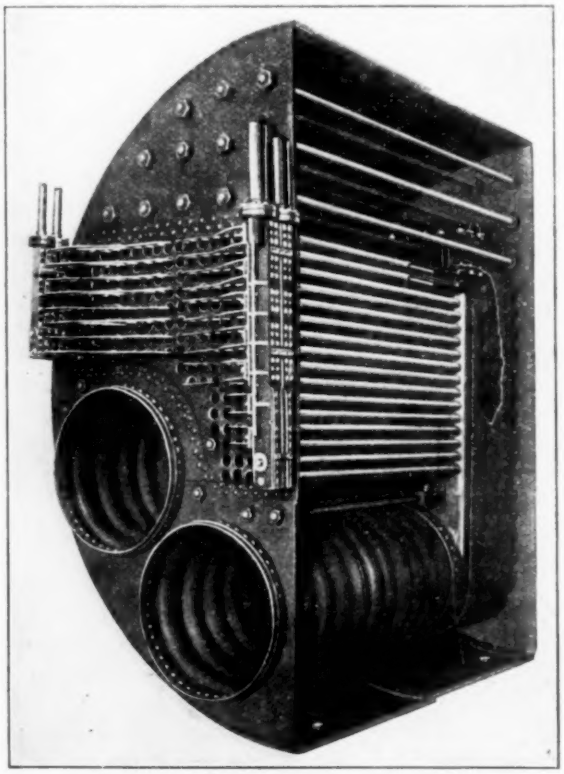


Fig. 9 Locomotive Superheater Co.'s Type "M" Superheater

of the tubes in the boiler from what would be fitted for saturated-steam operation. It is possible to do this because—

- *a* The tubes in Scotch marine boilers have a relatively low ratio of length divided by internal area, and
- *b* The gas area may be made more favorable, because of the flexibility permitted by the superheater design.

The question is many times asked how it is possible to insert superheater units in the tubes of Scotch boilers without retarding the draft. The explanation is not difficult to understand, when it

is realized that a reduction in fuel per hour of from 10 to 18 per cent is made possible through utilizing highly superheated steam. This means that the quantity of gas passing through the tubes is reduced in the same proportion as the quantity of fuel burned per hour, and that therefore a smaller area is sufficient if the same gas velocities are obtained. The obstruction caused by reduction in gas area, resulting from the insertion of the superheater units, is calculated in the design and in determining the diameter of the superheater pipe. The number of boiler tubes receiving the units, as well as the length of the unit, are varied to meet the conditions. It is also interesting to point out that the resistance of the gases passing the unit has, by careful test, been shown to be not more than the resistance encountered in passing a retarder having one turn. The use of retarders in marine practice is quite general, and they are frequently given from one and one-half to three turns. If a boiler fitted with retarders of two turns should be considered, it will be quite possible to remove the retarders, apply superheaters, obtain the fuel economies consistent with the type of prime mover used and, without increasing the air pressure from the fan, to burn, if occasion requires, a larger amount of fuel per hour and, assuming that the prime movers in the ship are suited, to obtain a very much greater indicated- or shaft-horsepower output.

The superheater installation in the S. S. *Cuba*, the first passenger vessel under the American flag to receive turbo-electric propelling equipment and to use high degrees of superheat, may illustrate more fully the points referred to. There were originally four Scotch boilers supplying saturated steam to triple-expansion engines of 2400 i.hp. These boilers were, if anything, small for the power to be developed. The space available in this vessel for the boiler room could not be increased without prohibitive expense and cutting down on the space usuable for other purposes. It was desired to provide 3000 shaft hp. in the new installation of propelling equipment, and the question immediately arose as to whether the boilers would be adequate. The substitution of turbines for reciprocating engines naturally effected an economy in steam, but without increasing boiler efficiency. The installation of fire-tube superheaters has not only increased the boiler efficiency, but has provided a more efficient working medium. The net result being that 3000 shaft hp. is being supplied from the original boilers.

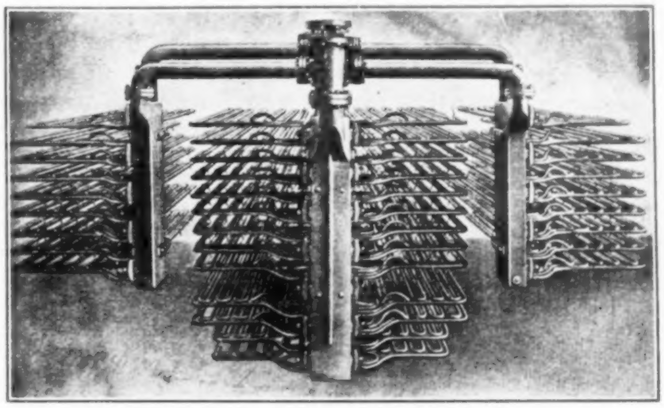
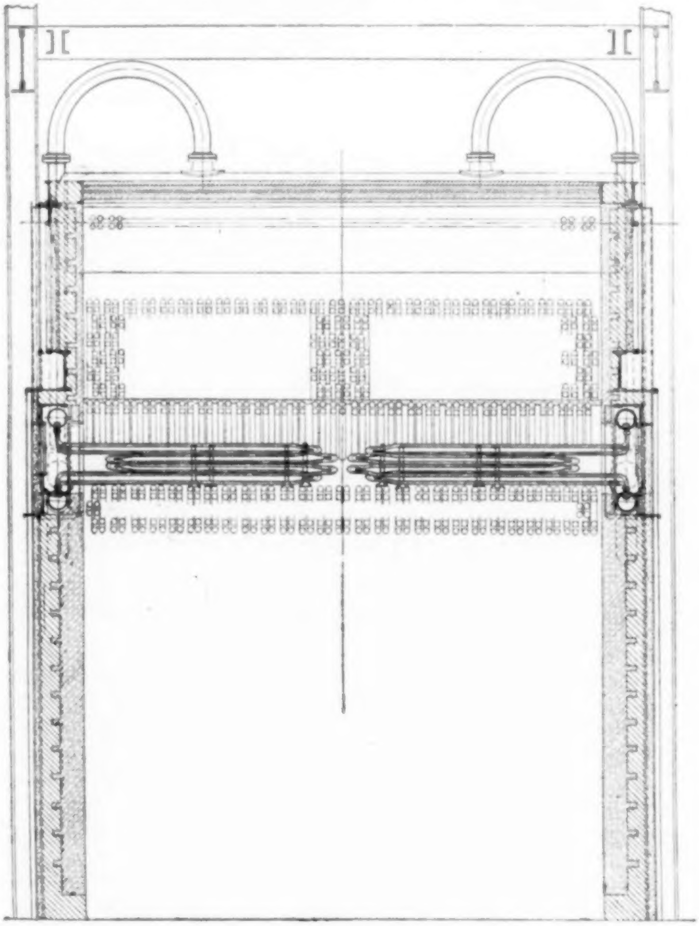


Fig. 10 Complete Superheater Withdrawn from a Scotch Boiler and Power Co. of New York

In the marine field, the adoption of superheaters has gone forward more slowly due to a number of causes which, previous to the world war, made the question of relatively less importance. American ships were not to any extent then in competition with vessels under foreign flags and fuel costs were comparatively insignificant. To-day this condition does not exist. Our war-built merchant fleet, which will be the nucleus of a greater American merchant marine, is now in competition on all seven seas against vessels flying other flags, and this competition necessitates the most careful study of operating costs. More than 75 per cent of the steam-driven merchant ships built abroad since the war have been fitted with super-



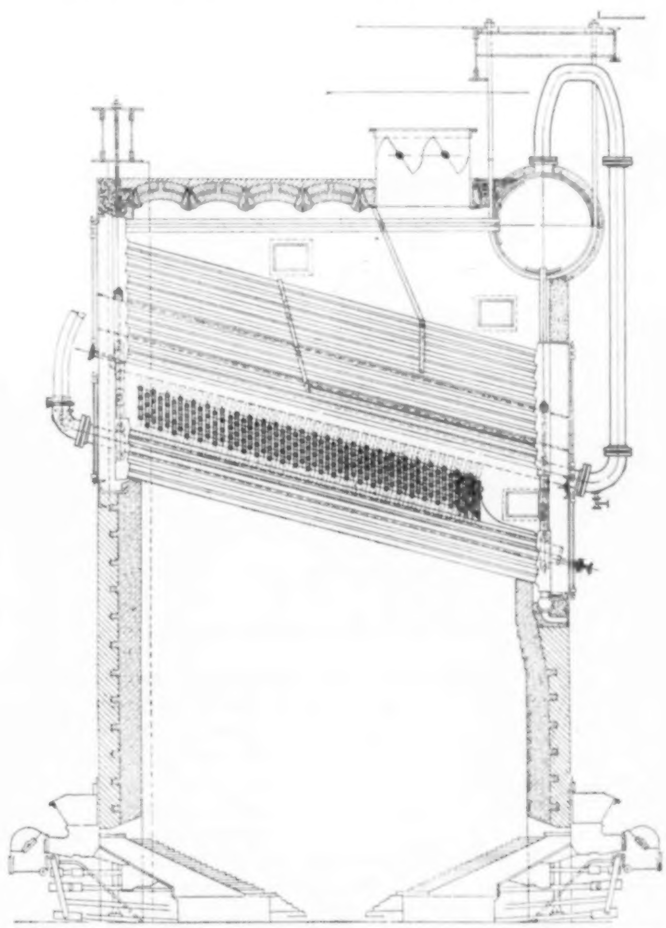


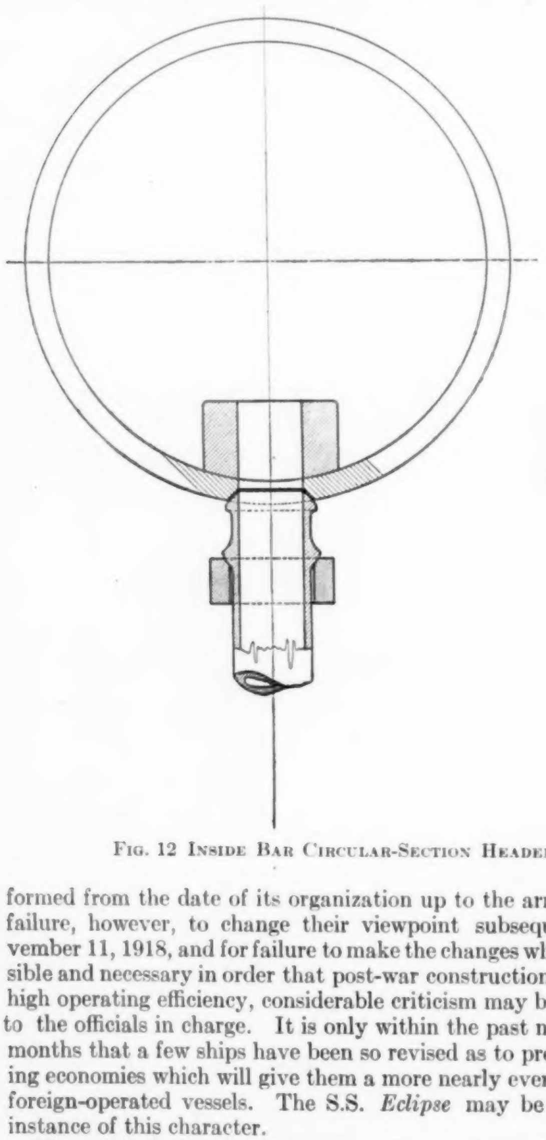
Fig. 11 Superheater for One of Twelve 1090-Hp. Water-Tube Boilers for the New Hell Gate Plant of the United Electric Light and Power Co. of New York

heaters, and fuel economies of from 12 to 18 per cent, depending on the type of propelling equipment, are being obtained by foreign operators. Fuel costs where they now are, or where they may be in the future, are compelling reasons why American marine engineers must adopt superheated steam, and other means of reducing fuel costs, or face handicaps which will militate against American success.

Many of those opposed to such betterment in operating conditions have contended that the personnel on American ships is unable to handle superheaters and equipment using superheated steam. To make such contention is a slander on American ability to do aboard ship what is being done in our power plants, and on locomotives.

It is doubtful whether our war-built vessels can be made quite as effective in the use of fuel as prewar construction. This statement is made without the intention of criticizing the colossal task which the Emergency Fleet Corporation and Shipping Board performed from the date of its organization up to the armistice. For failure, however, to change their viewpoint subsequent to November 11, 1918, and for failure to make the changes which were possible and necessary in order that post-war construction should have high operating efficiency, considerable criticism may be given fairly to the officials in charge. It is only within the past nine or twelve months that a few ships have been so revised as to produce operating economies which will give them a more nearly even chance with foreign-operated vessels. The S.S. *Eclipse* may be cited as one instance of this character.

The original decision of the Emergency Fleet Corporation at the beginning of their program called for low-capacity superheaters giving not over 50 or 75 deg. of superheat. It was believed that this would be adequate to provide protection for turbines. Had the specified amount of superheat been obtainable under the severe conditions existing at sea, such a program would have been correct and justified. The many instances of turbine blades cut by water, after but a few thousand miles of operation, demonstrated that low-capacity superheaters, under the conditions stated, failed to provide the protection which was necessary. It is difficult to understand why the known successful means of fuel economy, all the data for which were in the possession of the Emergency Fleet Corporation in 1917, have not been utilized in the post-armistice program. Not only would the protection to turbines have been assured, but economy in fuel and increased cargo space, vital as they are, would have been assured. The tonnage of iron and steel, critical as it is, would have been reduced 50 per cent, so far as the metal entering into the construction of superheaters was concerned.



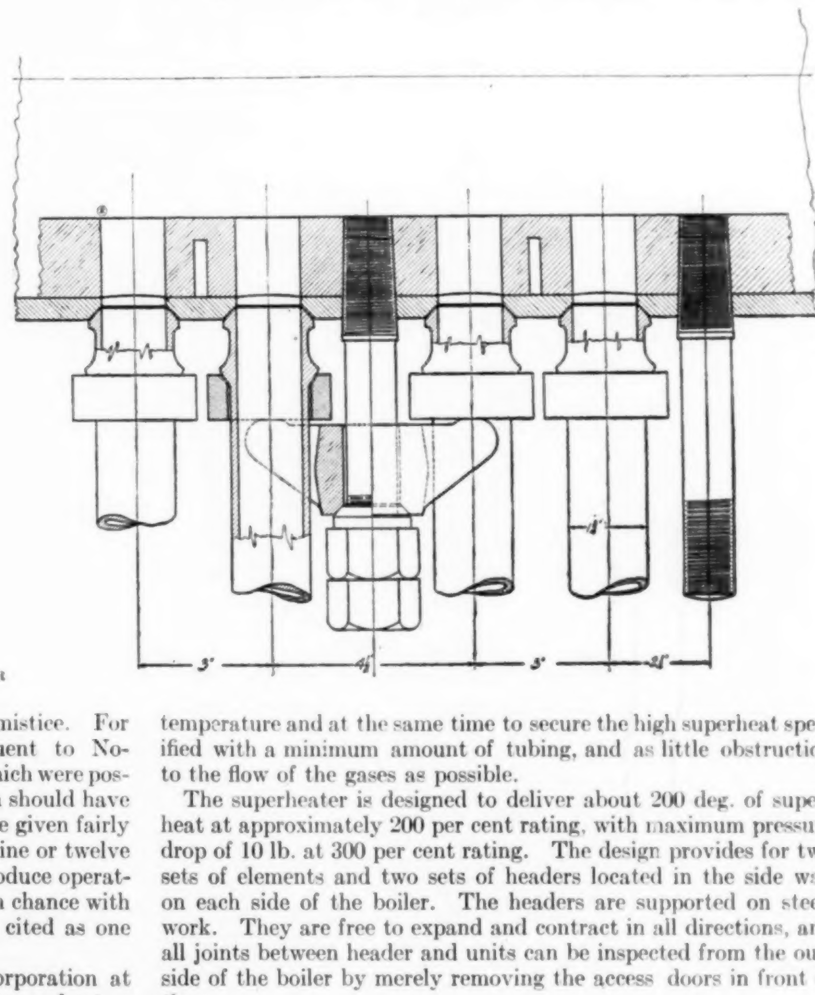


Fig. 12 Inside Bar Circular-Section Header

### A Late Example in the Stationary Field

The boiler shown in Fig. 11 is now being built by the Springfield Boiler Company for the new Hell Gate plant of the United Electric Light and Power Company of New York. The first installation will consist of twelve boilers. Space is provided for twelve more. When this plant is finished it will probably be the largest power plant in the world. The boilers are equipped with stokers on both ends and an adequate amount of combustion space is provided to make them capable to work at very high rating. The leading feature of this installation is the location of the superheater. Up to date all superheaters installed in this type of boiler have been arranged with the headers inside of the boiler, and with units located between the first and second pass, extending parallel to the boiler tubes. This new superheater arrangement is different from any other design in this country. The superheater is located in the first pass between the sixth and seventh row of tubes. The space is thus selected to protect the elements from too high temperature and at the same time to secure the high superheat specified with a minimum amount of tubing, and as little obstruction to the flow of the gases as possible.

The superheater is designed to deliver about 200 deg. of superheat at approximately 200 per cent rating, with maximum pressure drop of 10 lb. at 300 per cent rating. The design provides for two sets of elements and two sets of headers located in the side wall on each side of the boiler. The headers are supported on steelwork. They are free to expand and contract in all directions, and all joints between header and units can be inspected from the outside of the boiler by merely removing the access doors in front of them.

The elements are fastened to the headers by means of a detachable ball joint. They are equipped with forged return bends. Every unit can be removed from the boiler should necessity occur, without entering the boiler setting, and without disturbing any other portion of the boiler, other than the opening of an access door. Another feature of this superheater is the number of joints in the headers. There are only two joints for every 60 ft. of tubing, and there are only 204 steamtight joints in the entire superheater, as compared with other superheater designs which would have at least four times as many joints, including handholes.

Superheater headers are, in stationary and marine service, sometimes cylindrical in section, sometimes flattened on opposite sides, and in some designs are rectangular or square in section. The material is open-hearth steel.

Fig. 12 illustrates an "inside bar" circular-section header, and shows units connected to the header in a manner similar to the practice in use on all American locomotive superheaters. The units in stationary practice are of either the bare- or covered-tube type, the former predominating, although not to the extent found in railway and marine installations.

Fig 13 shows, in correct relation, sections and side elevations of various styles of units found in stationary superheaters. Relative bulk and weight may be easily compared.

The use of cores in superheater units is decreasing, for the reason that the practical disadvantages offset the theoretical advantages, particularly under bad water conditions. The second and third units of Fig. 13 have frequently been fitted with cores.

TABLE 2 TESTS MADE UNDER ACTUAL OPERATING CONDITIONS

(Machine shop only under constant load conditions at night. Tests made about two weeks apart with flues and approximately the same condition.)

| | Duration of Test—4 hours each | | | |
|---|---|---|---|---|
| | Saturated steam | Superheated steam | Increase per cent | Decrease per cent |
| Total coal consumed, lb | 9316 | 6827 | ... | 26.7 |
| Steam consumption, lb. of water | 57500 | 46000 | ... | 20.0 |
| Avg. steam pressure of boilers, lb | 118.0 | 115.0 | ... | 2.5 |
| Avg. load on Corliss engine, i.hp | 43.0 | 43.6 | 1.4 | .. |
| Avg. load on Woodmill engine, i.hp | 43.2 | 42.8 | ... | 0.9 |
| Avg. load on electric generator, kw | 56.7 | 56.8 | 0.2 | .. |
| Revolutions of air compressor, total | 26590 | 26630 | 0.1 | .. |
| Boiler hp. developed | 386 | 336 | ... | 12.9 |
| Per cent rated capacity developed | 107.0 | 93.3 | ... | .. |
| Temp. of feedwater, deg. fahr | 212 | 207 | ... | 2.4 |
| Heat value of 1 lb. coal, B.t.u | 13510 | 13190 | ... | 2.4 |
| Degrees superheat, main header | ... | 163 | ... | .. |

## Operating Conditions

To go into the details of operating conditions would require more space than is available, and only a few of the more important factors will be referred to.

Increased steam temperature makes necessary provision for greater expansion of pipe lines, expansion joints, etc., than where saturated steam is used. In installing superheaters in existing plants, it is therefore necessary to determine what expansion is

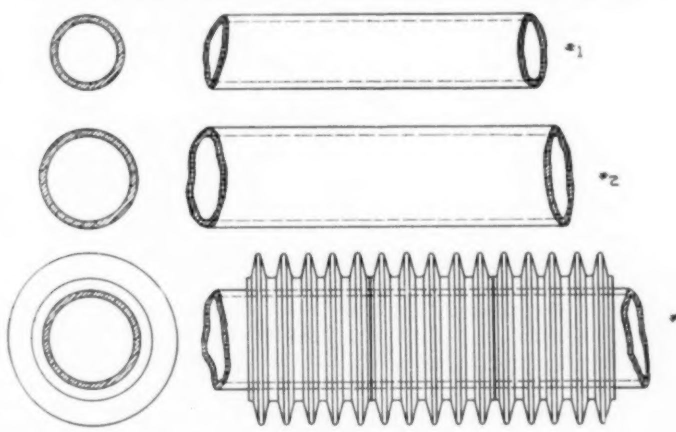



Fig. 13 Styles of Units Found in Stationary Superheaters

provided for, and if not adequate, provision must be made, or pipe-line difficulties will ensue.

Where reciprocating engines are using superheated steam, the valves must be of proper design and material, and suitable lubricating conditions must be provided by using oil of proper quality.

When turbines are to change from saturated to superheated steam, it is necessary to know that the turbine design is suitable, and what degree of superheat may be used without distress.

## Results Obtained

In locomotives, upward of 20 per cent in fuel economy is believed conservative as applying to the 33,000 locomotives, with high-degree superheaters now operating on the United States railroads. Road tests of locomotives are more difficult to carry out with the accuracy obtainable from stationary plants, but comparative results, on which conclusions may be reached, have fortunately been available through testing plants of the Pennsylvania R. R., Purdue University and University of Illinois.

Fig. 14 shows indicator cards obtained from the Pennsylvania test results, which indicate the steam economy for equal horsepower, and Fig. 15 shows the increased horsepower for comparable rates of evaporation. The steam economy shown is 30¼ per cent, and the increase in horsepower for a given evaporation is 45.1 per cent.

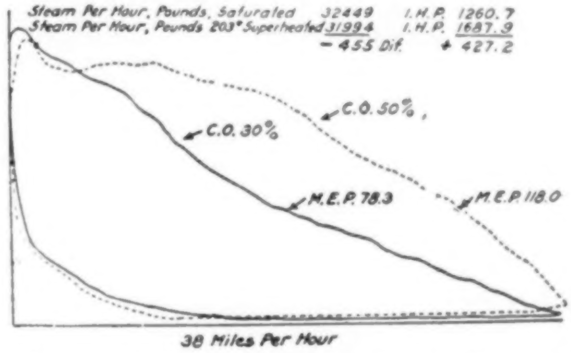



Fig. 14 Indicator Cards Obtained in Pennsylvania Railroad Tests, Showing Steam Economy for Equal Horsepower

In marine service interesting data have been collected, generally from the owners, for over fifty vessels ranging from 2800 to 16,000 deadweight tons cargo capacity, some driven with reciprocating engines, some with geared turbines, and some having turbo-electric drive. Thirty-eight of these ships provided with superheaters averaged a coal consumption of 3.3 lb. per 100 dead-

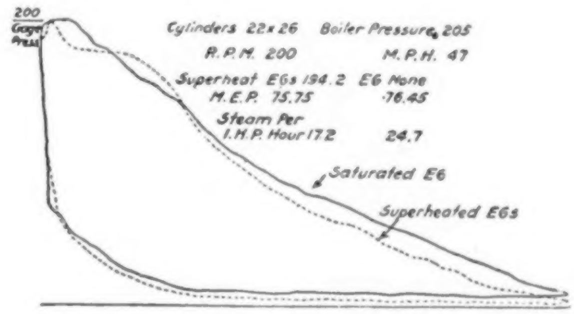



Fig. 15 Indicator Cards Obtained in Pennsylvania Railroad Tests, Showing Increased Horsepower for Comparable Rates of Evaporation

weight ton-miles, while for fifteen not so equipped the fuel consumption averaged 5.28 lb. per 100 deadweight ton-miles. Comment on these figures would be superfluous.

The results obtained by using superheated steam in stationary power plants are more numerous, and very complete accounts of carefully conducted tests have filled the pages of the technical papers for a number of years.

Table 2 is believed to be of more than ordinary interest as it indicates the savings obtained by superheater installation in a railway power plant. As might be expected, fuel economies are high due to the fact that the character of work performed by the steam in plants of this kind is varied, and, of necessity, inefficient at best. It is well known that economies obtainable from superheated steam are more pronounced when the steam is originally used less effectively, and fuel savings for a given degree of superheat are greater for simple and compound engines and less for turbines and triple-expansion condensing engines.

In the railway field, where its adoption and extension has been most rapid and complete, there is a strong desire to go to even higher degrees of superheat than formerly, and hundreds of our locomotives are operating with steam at temperatures beyond any ordinarily found in either stationary or marine service.

The belief of many engineers, strengthened by considerable study of the problem, is that steam of 800 deg. fahr. temperature is adaptable for general use, and that the results will be entirely justified and will prove gratifying to owners and operators of such plants.

# The Possibility of Improved Methods of Rolling Sheet Steel

By SUMNER B. ELY,[1] PITTSBURGH, PA.

PROBABLY the first iron plates were made by hammering and must indeed have been a crude production. About 1725–1730, however, rolls seem to have come into use, although it was a number of years later before anything resembling a thin sheet was made. Yet from that day to the present time the same general type of machinery has been used for rolling sheet steel. To be sure, our sheet mills of today compared with the early ones would appear giants in size and strength, yet after all what real difference is there except this increase of size and strength? We have no continuous sheet mills, we do not even use roller-driven tables, automatic guides, etc., and practically everything is done by hand.

This statement may need a little qualification. Occasionally we do come across some small devices in use. Such, for instance, as a hinged or pivoted table to assist the catcher returning the pack over the top of the rolls to the roller. This particular device does not save any labor, in the sense of fewer men being employed; it is merely a help to the catcher. Some devices, such as shifting tables, and auxiliary attachments to cold rolls, may have a tendency to cut down the labor force; but after all such small helps as these are not real changes in the machinery of sheet rolling, and furthermore are far from being universally used.

It would seem, however, as if some device might be gotten up to cut down the number of men needed about a sheet mill. A mechanical catcher, for example, which would automatically catch the pack of sheets as it came through the rolls, lift it up and return it to the roller again. Such a device would seem to be a mechanical possibility and probably could be made to work successfully, but the amount of saving it would effect has apparently not been sufficient to act as a real incentive.

### Importance of Proper Heating in Sheet-Steel Rolling

In the manufacture of heavier steel products the temperatures to which they are heated are high, comparatively, and there is some latitude; but with sheet steel the heat must be just right. Even starting with the bar, say, as it comes from the furnace for the first pass in the mill, if it is too cold the scale will not be lifted and this scale rolls into the sheets, making rough surfaces and causing them to stick together when later they are rolled in packs. If the sheet mill could receive only bars that were perfectly clean, no harm might be done even if the heat was a little too cold; but all commercial bars carry scale and this, of course, must be taken into account.

However, if instead of the bar coming too cold from the pair furnace, it is a little too hot, then there is still worse trouble; for the large sheet rolls will get hotter than the roller anticipated, will expand and the line of contact between them will not be correct; and in addition, as the bar is too hot it will be softer than it should be, and will not spring the rolls the desired amount. The consequence of this is that the bar when worked down on the chill rolls will produce a sheet round on the back end, that is, thinner in the center than at the sides; whereas, probably the bar that preceded it had the proper temperature and produced a sheet that was not long in the center, but long on each side, having what the roller calls "horns." A round-end sheet indicates that the rolls are "full" in the middle and horns show that the rolls are "hollow." Now when a circular-end sheet is placed on top of a horned sheet and the two are reheated and put into the rolls together, the pack will either pinch or run off at the back end, that is, the sheets will spread one from another on the back end of the pack, due to the uneven drawing.

And even if the roller by great care and judgment in adjusting the draft screw is able to prevent a pinch, the scale which is produced by excessive heating will only lift in spots, sinking into the sheets and causing the pack to stick together in patches, so that the sheets cannot be pried apart without tearing.

Every one familiar with sheet rolling realizes that the rolls must be kept at the proper heat so that they will maintain the proper shape to successfully roll such a thin product. A roller may (probably unconsciously) count on a certain spring to a stand of rolls and by trial find the proper heat to go with it, so as to keep the shape of his rolls right; and he will watch carefully the size of the horns on each sheet as this is an indication of the shape of the mill. He knows that if he rolls too fast—does not allow time enough between passes—his rolls will lose their shape. Neither must he roll too slow. Again, sheets always entered at the same place on the roll may cause trouble. He must constantly watch and guard against such things as cold drafts of air blowing on the rolls, in fact, anything that will in any way effect the temperature of the roll.

Of late years some of these difficulties have been helped by burning gas against the rolls to expand them when not in operation or by blowing steam on working rolls in order to keep down the expansion.

### Roll-Neck Friction an Important Factor

Another most important factor is the roll-neck friction and it is not always appreciated how much this amounts to. For example, when finishing a pack if one neck of a roll be greased (with hot neck grease) without greasing the other, the pack will always draw a long horn next to the neck that is dry. The reason is that the friction on the ungreased neck is greater and consequently heats and expands the roll on that side. The author has reason to think that anywhere from 60 to 90 per cent of the power required is used in overcoming roll-neck friction, although there are no definite figures to go on. This is one of the most important things in roll design and yet there is no scientific information available on the subject; if there were it might lead to some radical changes.

Prof. W. Trinks of the Carnegie Institute of Technology has plans for building an experimental rolling mill which is arranged so that each factor entering into the problem of rolling can be controlled; and it is hoped that such a mill will be installed, for there is great need of definite figures in connection with all steel rolling generally. The apparatus devised for the purpose of determining roll pressures and spreading forces in this mill was described at length in Mechanical Engineering of January 1920 (pp. 11–13), by W. B. Skinkle, at that time Director of the Bureau of Rolling Mill Research of the Carnegie Institute of Technology.

On hot-roll sheet mills at work a blue or indigo color is often observable and this will correspond to a temperature of about 550 deg. fahr. This temperature will often run higher, although when reaching 750 deg., showing a gray, the roll is liable to break shortly afterward. In a totally dark room probably 900 deg. fahr. would give the roll a perceptible red color. Naturally the roll is hotter in the center than at the ends and the necks are still cooler; for although grease is often seen burning on the neck, yet the temperature at which it burns is generally lower than the temperature of the roll as indicated by its color.

In the history of sheet rolling there has been a tendency to continually increase the diameter of the rolls, until today sheet rolls of 30 in. are seen, and the author understands rolls as large as 32 in. have been used. The larger the roll the more tonnage can be turned out, as the large roll does not change its temperature as readily as a small one. There is evidently a limit to the size however (aside from practical considerations of handling such heavy rolls), for the larger the roll the more the radiating surface to cause cooling. The fact that the volume varies as the cube and the

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Condensed from a paper presented at a joint meeting of the Pittsburgh Section of The American Society of Mechanical Engineers and the Engineers' Society of Western Pennsylvania, April 26, 1921.

surface only as the square of the diameter, has only an indirect relation to this problem of cooling. It is also to be borne in mind that the larger curvature will not draw the steel as much for the same total pressure.

As far as the breakage of rolls is concerned, this is apparently due to unequal expansion, and not to the stress of rolling—as evidenced by the fact that rolls sometimes break when the roll is standing still, the roll train perhaps having been stopped for a few moments during the working period.

### The Possibility of a Continuous Sheet Mill

Considering now the possibility of a continuous sheet mill, it will be remembered that about fourteen years ago the U. S. Steel Corporation spent a very large sum of money at South Sharon, Pa., and installed a continuous sheet mill which consisted of a series of stands of ordinary two-high rolls in tandem; the sheet passing through one stand after another, never being in two stands at the same time; and the sheets were automatically doubled and matched together in special devices at certain points in the train. After a most thorough trial, however, the mill was dismantled and the ordinary method of sheet rolling installed.

This is a convincing and definite proof of the great difficulties of sheet manufacture by using our present roll stands in a continuous train. Aside from any other question, the difficulty of keeping so many different rolls in a like expanded condition and shape seems insurmountable. The present method of using gas and steam on rolls which was not known at that time, might have aided a little; but something much more certain than this must be devised if light gages are to be rolled in this manner. Possibly the heavier gages, 10 and 12, say, could be made in this way; but we already have satisfactory mills of a different type for this purpose and we would be no further along toward automatically rolling light-gage steel.

Some method of absolutely heating the steel to a definite temperature, possibly some form of electric furnace, and some way of keeping the shape of the roll, must be devised. Rolls have been cast with holes through the centers and steam introduced or gas burned inside them; but they have been found inadequate to hold their shape and stand up to the service. The practice already mentioned of using gas and steam on the surface of the rolls is more satisfactory. Perhaps some day rolls will be placed inside a constant-temperature furnace; but what would be done about the bearings and other details is a question which as yet has not been answered.

### A Successful Austrian Continuous Sheet Mill

Some twelve or more years ago the author visited a continuous sheet mill in the town of Teplitz in Northern Austria. This is an extremely interesting mill and the only one of its kind he ever heard of. There are five stands of two-high continuous rolls, all being alike, having a diameter of 23 $^5/_8$ in. and a length of 59 in. In front of this is a small set of three-high rolls, and to the right a larger set of three-high rolls. An 8-in. slab is delivered to the large three-high mill and broken down to 3 or 4 in. thick. This slab is then cut in half and put into a reheating furnace. One of the halves then goes to the small three-high mill and is reduced to $^9/_{32}$ in. (7 mm.) thick and then without reheating is put into the continuous stands. This thickness ($^9/_{32}$ in.) is always the same and the reduction is varied on the continuous mill to give the required final thickness.

The sheet is finished about 60 ft. long and is of course in all the stands at the same time. Sheets are always rolled singly and never in packs or doubled, and are from 40 to 50 in. wide. The stands are about 9 ft. from center to center and no idle rolls or automatic tables of any kind are used, simply stationary guides 6 or 8 in. high and a cast-iron plate between the stands on which the sheet slides. The gear train gives the first stand rolls 30 r.p.m., the next $37^1/_2$, then 45, $52^1/_2$, and finally 60 for the last stand. When the author saw the mill it was rolling a final product of 12 gage, making a total reduction in the five stands of some 58 per cent (from 7 mm. to 3 mm.).

Several points of great interest present themselves in connection with this mill. The first is the fact that such a thin piece of steel could be in all the five stands of rolls at the same time and not either tear or be crumpled between them. There is a great deal of confusion as to the pull exerted by rolls generally on steel, but as a matter of fact there is little if any pulling action, assuming of course the steel to be free and not held by any outside force. The resultant of the various forces acting on the steel must be vertical; for if it were inclined there would be an unbalanced horizontal component which would cause acceleration, making the bar go faster and faster. As such an action does not occur, this resultant force must be vertical. And therefore if the speeds and drafts are correct among the various stands of rolls, the sheet will not "pull" itself to pieces going into the rolls, assuming of course that the shape of the rolls is also right.

This continuous mill has demonstrated the fact that not only can the shape of the rolls be controlled but the speeds and drafts among the various stands can be properly adjusted, at least for single sheets as thin as 14 gage.

Another point of great interest is the fact that the back end of the sheet comes out thicker than the front end, due to the rapid loss of heat while in the continuous rolls. The finished sheets are respectively 2.5 mm. and 2 mm. thick at the edges at the back and front ends and 60 ft. long. To operate this mill economically it must work these long lengths and it is their practice to cut the 60-ft. sheets into short pieces, and afterward sort together the corresponding thicknesses from the different long lengths of finished sheets so that the variation of thickness will not be noticeable to customers.

The author was told that the mill was not a great financial success as there was not demand enough to keep running steadily on these particular gages. Further, the engine running the continuous mill was of about 1000 hp. normal rating and totally inadequate to run the mill satisfactorily.

Little experimenting had been done in trying to roll two sheets in a pack, for the furnace layout made it almost impossible to do so. However, the little that had been done seemed to show, as one would expect, that the thinner the sheet the greater the non-uniformity of thickness. It would seem that a reversing two-high mill, receiving alternately the hot and cold ends of the steel, might equalize this thickness and possibly be more satisfactory than the five continuous stands. So the question would naturally arise as to the best method to employ in rolling 12- and 14-gage sheets.

Then, too, it would be impossible to take this 12- or 14-gage material rolled on a special mill and finish it on the ordinary two-high sheet mill. Shapes of sheets and rolls will not fit, and while one of two packs might be rolled with care, the scrap loss would be enormous and this has been tried commercially and failed. It has also been suggested and thought possible to reduce the cost of sheet rolling by starting with the product from a universal plate mill instead of a sheet bar mill. If a universal plate of 7 or 8 gage and of accurate width were cut to proper size it would be equivalent to doing away with some of the present roughing-down process. However, when the price of universal plate is taken into account there is little or no gain; and in addition the difficulty of doing good work has been very greatly increased.

At first thought it would seem that sheets might be successfully rolled in packs on a two-high reversing mill. The condition of the same two rolls in the same relation to each other and the same pack of steel is what we have in the commercial mill now; and certainly with reversing roller tables, etc., a large saving in labor would result, even if the tonnage per set of rolls was not increased. However, it must be remembered that in a reversing mill first one end of the pack and then the other would be entered; and that this thin pack of sheets would have to be first drawn in one direction and then in the opposite direction; and that the two ends of a pack are not alike. So that we really have a very different condition from the ordinary two-high stand.

This sheet-machinery problem is a real problem, but as the author sees it, the only logical way of approach is from the scientific experimental side. It has been pretty well demonstrated that practice cannot furnish enough information. We need more knowledge of what actually occurs in rolling, what are the pressures, heat distribution, radiation, friction, etc., and when enough data and information are at hand, new ways and means, as always happens, will be indicated.

# Relative Efficiency of Various Types of Condensing Apparatus

## Results of Comparative Tests Carried Out on Double-Pipe Coils, Submerged Coils With and Without Manifolds, and Cooling Towers, and of Value as a Guide in the Selection And Design of the Most Efficient Type of Condenser

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Among the many problems confronting engineers today there is none of more vital importance than that of improving the efficiency of condensing apparatus used in connection with the distillation of various liquids. However modern may be the process of distillation in practice, it will continue to fall short of its ultimate purpose—increased production—if the condensers in use are unable to stand forcing or are inadequate in their ability to perform the heat transfer and cooling required. The subject of heat transfer or conduction through metal with oil or oil vapor as one of the mediums has been mentioned by Dean P. F. Walker, of the University of Kansas in his paper, The Need of Research in the Industrial Field,[3] as a problem of frequent discussion among refining engineers; the latter without a doubt having had the condenser in mind throughout.

In order to arrive at conclusions concerning this problem which would ultimately be of value as a guide in the selection and design of the most efficient type of condenser, certain experiments have been carried out by the authors on a number of the most general designs of such apparatus for the purpose of obtaining data indicative of the relative efficiency of each. On account of the difficulties in construction that would have arisen, as well as the variation in operation, had any vapor other than steam been used as a medium to be condensed, it was considered best to carry out all tests with low-pressure steam. It is quite evident that the relative ability of each type of condenser as far as heat transfer is concerned is the same whatever the vapor passing through it; therefore the authors have felt justified in having conducted their experiments using the most uniform vapor available, i.e., steam.

### Types of Apparatus Tested

Four types of apparatus were tested, namely:
- Double-Pipe Coil
- Submerged Coil, Not Manifolded
- Submerged Coil, Manifolded
- Cooling Tower.

Descriptions of these immediately follow.

*Double-Pipe Coil.* Built of 2-in. pipe within 3-in. pipe. Length of 3-in. pipe between fittings, 18 ft. 2 in.; effective length of 2-in. pipe, 19 ft. 2 in.; overall length of coil, 20 ft. 2 in.; height, 6 ft. 3 in.; area of cooling surface, 146 sq. ft. Coil supported vertically between two sets of 3-in. pipe driven into the ground with holes drilled at proper intervals to support bolts for the coil pipes. Solid-end fittings manufactured by the York Manufacturing Company for refrigeration purposes were used. Eleven sets of fittings in all with extra inlet and outlet fittings. Low-pressure steam used in all runs on this apparatus. Steam inlet at top of coil to pass between 2-in. and 3-in. pipes. Condensate outlet to bottom of coil and therefrom to tank and scale for weighing. Cooling-water inlet at bottom of coil within the 2-in. pipe. Outlet at top of coil, thence to ditch. All cooling water taken from hydrant line and metered.

*Submerged Coil, Not Manifolded.* Built of 30 lengths of 2-in. pipe, 8 ft. long, joined together with standard return bends. Arranged in a coil five pipes high and six pipes wide. Total area of cooling surface, approximately 162 sq. ft. No manifold fitted, therefore same steam particles entered at top and passed back and forth through all the pipes to leave the outlet at the bottom and flow to a tank and scale for weighing. Coil set in a steel tank 2 ft. 4 in. high, 3 ft. 9 in. wide and 10 ft. long. Seams of tank doped to prevent leakage. Cooling water taken from hydrant line via meter and 2-in. pipe to the bottom of the above-mentioned tank. Water overflow at top of tank via 3-in. pipe to ditch. As close to counterflow as possible in such an apparatus was thus obtained. Size of coil overall, 20 in. high by 24 in. wide

*Submerged Coil, Manifold Type.* Built of 30 lengths of 2-in. pipe, 8 ft. long, manifolded at inlet and outlet into five sections of six pipes each. Intermediate connections of all piping was made with standard return bends. Total area of cooling surface was approximately 162 sq. ft. Live steam used due to lack of available exhaust steam. Steam inlet at top of coil via manifold. Controlled by a valve and gaged. Condensate outlet via bottom manifold and thence to a tank and scale for weighing. Coil set in a steel tank 3 ft. 2 in. high, 2 ft. 1 in. wide and 10 ft. long. Seams calked with asbestos packing to prevent leakage Cooling water taken via hydrant line and meter and 2-in. pipe to the bottom of the tank. Water overflow at top of tank via 3-in. pipe to ditch. As close to counterflow as possible in such as apparatus was thus obtained. Overall size of coil, 23 by 23 in.

*Cooling Tower.* Built of 2-in. malleable iron pipe and standard fittings, three pipes wide, nine pipes high (i.e., three nine-pipe sections) with manifolded inlet and outlet. Overall lengths of pipes, 8 ft.[1] Distance center to center horizontally 19 in., vertically, 8 in. Approximate area of cooling surface, 146 sq. ft. (including horizontal pipes, vertical nipples, standard fittings and manifold fittings, etc.) Overall height of coil, 5 ft. 3 in., length 8 ft. 5 in., width 3 ft. 9 in.

Cooling-water distribution over the tops of the coils was carried out by means of a 2-in. inlet pipe, taking water from hydrant line via a meter and thence to a tin distributor box at the opposite end of the coil from where the steam entered. Flow of both steam and cooling water was parallel; i.e., from top to bottom. From the distributor box the cooling water was fed to the top pipes of the coil by means of wooden troughs, having a canvas strip in the apex of each. These troughs were easy to adjust to obtain equal and uniform flow over the coil, the water flowing over the top of each trough and dripping down the canvas strip on the top pipe and thence in sequence to the lower runs of pipe. It was attempted to obtain a certain amount of counterflow by installing a series of six garden-hose nozzles attached vertically to $^3/_4$-in. piping fed by the main cooling-water supply and controlled by a valve. This proved, however, to have no material advantage and to be beyond proper control.

Wood baffling 4 in. on centers constructed to uprights at each corner of the coil was installed around the entire apparatus to do away with splash and still provide free access for the air. Exhaust steam of 5 in. pressure was used, being led to the coil via a top manifold and controlled by a valve. Condensate outlet was via a bottom manifold and thence to a barrel and scale for weighing. Steam was trapped and pipes covered to obtain as dry steam as possible. All cooling water used was taken from the hydrant and metered.

### Method of Conducting Tests

Inasmuch as the ultimate purpose in view throughout the experiments in question was to obtain a knowledge applicable to the design of practical condensing apparatus of maximum efficiency for condensing oil, vapor and cooling the resultant condensate to final temperatures in the neighborhood of 100 deg. fahr., all data were taken with this point constantly in mind. Low-pressure steam of an average quality of 98 per cent was used throughout as the condensing medium. In every case four variable factors presented themselves for consideration, namely:

- Temperature of cooling water entering condenser
- Quantity of cooling water
- Temperature of condensate
- Quantity of condensate.

There was as well a certain variation occurring in the heat content and temperature of the steam, but not of sufficient amount to materially influence the results obtained. Throughout the experiments the temperature of the inlet cooling water was held as constant as possible, thus eliminating this variable from further consideration. Three separate series of tests were therefore carried out on each type of condenser, maintaining one of the three remaining variable constants in each case, namely:

1 Volume of condensate constant; temperature of condensate and volume of cooling water varied

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[2] Mechanical Engineer, The Texas Company.

[3] Mechanical Engineering, September 1920, p. 487.

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[1] See Bureau of Mines Bulletin No. 176, page 36: "It is well when possible to place pipes in a continuous coil so that an air space not less than twice the diameter of the pipe will be left vertically between pipes of the same coil, and a space 8 to 10 times the diameter of the pipe will be left open horizontally between sets of coils."

2 Temperature of condensate constant; volume of cooling water and volume of steam varied

3 Volume of cooling water constant; temperature of condensate and volume of condensate varied.

## Results Obtained in the Tests

The results of the tests are given in Table. In every series the order of efficiency was practically the same, namely:

1 Double-Pipe Coil
2 Submerged Coil, Not Manifolded
3 Submerged Coil, Manifolded
4 Cooling Tower.

The results cannot be assumed as indicative of the capacity of various condensers under practical conditions, inasmuch as in some cases it required as high as 40 lb. pressure to force the steam through the coils. The data are intended purely to show a comparison of efficiency and relative heat transfer.

A comparison of the manifolded and non-manifolded submerged coils indicates the same limitations. In fact, even through the efficiency of a non-manifolded coil is the higher, yet it may be necessary in practical operation to manifold the coil in order to provide adequate area for flow; although this must be done at the expense of a decrease in heat transfer.

The double-pipe coil gives the nearest perfect counterflow of the mediums as is indicated by the high outlet-water temperature and low condensate temperature. In the submerged coil perfect counterflow cannot be gained, but a partial effect is obtained by putting the inlet water entrance at the bottom and at the opposite end of the coil from the steam inlet which is located at the top of the coil. The data show a cooler outlet water and warmer condensate than for the double-pipe coil. The handicapping feature of the cooling tower is that an unavoidable parallel flow of the mediums exists; and a high outlet temperature of condensate prevails.

The possibility of spraying the outside of the double-pipe coil is worthy of mention and consideration in the construction of a practical condenser. No actual data were taken to support this contention in the experiments in question, but it was noticed that a marked heat transfer by evaporation was clearly evident on several occasions when the apparatus was operating and showers occurred.

There is one advantage held by the cooling water which must not be overlooked, namely, the fact that evaporation is used for carrying away the major part of the heat, only a small amount being transferred as sensible heat to the cooling water. This is a practical advantage if the cooling water is to be spray-cooled and reused. The effect that weather conditions have on the coils is marked. When humidity is high, when there is rain or little breeze, evaporation will be decreased and vapor clouds hang heavily around the coils. Most efficient operation was found to occur when a light breeze prevailed and the air was dry.

In conclusion, the following points may be emphasized as being brought out by the data obtained in the tests:

1 On a basis of heat transfer the double-pipe coil is far superior to any of the other types of condensers tested; the degree of superiority and the comparative efficiencies of the others being shown clearly by the resultant curves.

2 Considering the submerged coils, the non-manifolded type of apparatus shows a better heat transfer than the manifolded coil under like operating conditions.

3 On a basis of low outlet temperature of the cooling water, the cooling tower is much superior to other coils, as the data indicate. This characteristic is of value if the cooling water is to be cooled and reused.

TABLE 1 DATA OBTAINED IN TESTS OF VARIOUS TYPES OF CONDENSERS

| Length of test, min. | Temp. of inlet water, deg. fahr. | Temp. of outlet water, deg. fahr. | Steam pressure, lb. per sq. in. | Temp. of steam, deg. fahr. | Temp. of condensate, deg. fahr. | Cooling water per min. gal. | Condensate per min. lb. |
|---|---|---|---|---|---|---|---|
| **Constant Flow of Condensate** | | | | | | | |
| *Double-Pipe Coil:* | | | | | | | |
| 60 | 86 | 210 | 5 | 228 | 95 | 5.0 | 8.3 |
| 60 | 86 | 209 | 5 | 228 | 91 | 6.1 | 8.5 |
| 60 | 90 | 207 | 5 | 227 | 89 | 6.5 | 8.2 |
| 60 | 90 | 206 | 5 | 226 | 88 | 7.9 | 8.5 |
| 60 | 87 | 202 | 5 | 228 | 88 | 9.5 | 8.4 |
| 60 | 86 | 193 | 5 | 223 | 87 | 10.8 | 8.6 |
| 60 | 86 | 178 | 5 | 225 | 86 | 12.8 | 8.4 |
| Avg. | 87.3 | 200.7 | 5 | 226.4 | .. | .... | 8.4 |
| *Submerged Coil, Not Manifolded:* | | | | | | | |
| 40 | 92 | 139 | 4 | 226 | 96 | 29.4 | 8.4 |
| 40 | 94 | 146 | 4 | 226 | 96 | 23.8 | 8.3 |
| 40 | 94 | 141 | 5 | 227 | 97 | 20.7 | 9.3 |
| 40 | 94 | 158 | 5 | 227 | 98 | 16.3 | 8.9 |
| 40 | 95 | 168 | 5 | 227 | 99 | 13.2 | 8.5 |
| 40 | 94 | 172 | 5 | 227 | 102 | 8.9 | 8.3 |
| 40 | 94 | 181 | 5 | 227 | 106 | 5.0 | 8.7 |
| Avg. | 94 | 158 | 4.7 | 226.7 | ... | .... | 8.6 |
| *Submerged Coil, Manifolded:* | | | | | | | |
| 60 | 90 | 192 | 5 | 227 | 120 | 4.8 | 8.2 |
| 60 | 90 | 194 | 5 | 227 | 113 | 10.4 | 8.4 |
| 60 | 90 | 177 | 5 | 227 | 106 | 15.6 | 8.4 |
| 60 | 90 | 153 | 5 | 227 | 103 | 19.6 | 8.9 |
| 60 | 91 | 141 | 5 | 227 | 102 | 22.9 | 8.4 |
| 60 | 91 | 135 | 4 | 226 | 102 | 29.8 | 8.5 |
| Avg. | 90.3 | 165.3 | 4.8 | 226.8 | ... | .... | 8.5 |
| *Cooling Tower:* | | | | | | | |
| 60 | 92 | 110 | 5 | 223 | 108 | 23.7 | 8.8 |
| 60 | 92 | 111 | 5 | 222 | 110.5 | 21.9 | 8.0 |
| 60 | 92 | 112 | 5 | 224 | 111 | 20.9 | 8.2 |
| 60 | 92 | 113 | 5 | 224 | 112 | 18.8 | 8.3 |
| 60 | 92 | 115 | 5 | 224 | 113 | 16.8 | 8.5 |
| 60 | 92 | 120 | 5 | 219 | 118 | 12.9 | 8.7 |
| 60 | 92 | 127 | 5 | 220 | 119 | 11.9 | 8.8 |
| Avg. | 92 | 115.4 | 5 | 222.3 | ... | .... | 8.5 |
| **Temperature of Condensate Constant** | | | | | | | |
| *Double-Pipe Coil:* | | | | | | | |
| 40 | 90 | 211 | 4 | 225 | 96 | 5.1 | 5.0 |
| 40 | 90 | 211 | 12 | 244 | 96 | 7.9 | 10.1 |
| 40 | 91 | 214 | 20 | 259 | 96 | 11.3 | 13.7 |
| 40 | 91 | 213 | 24 | 265 | 96 | 16.3 | 16.4 |
| 40 | 91 | 210 | 30 | 274 | 96 | 24.8 | 19.9 |
| 40 | 91 | 195 | 40 | 287 | 96 | 36.3 | 28.0 |
| Avg. | 90.6 | ... | .. | ... | 96 | .... | .... |
| *Submerged Coil, Not Manifolded:* | | | | | | | |
| 60 | 95 | 148 | 5 | 228 | 97.5 | 10.5 | 2.9 |
| 90 | 90 | 172 | 5 | 229 | 92.0 | 9.7 | 4.3 |
| 60 | 93 | 142 | 5 | 227 | 95.5 | 13.3 | 5.8 |
| 60 | 94 | 149 | 5 | 228 | 94.5 | 17.3 | 7.9 |
| 90 | 91 | 161 | 5 | 229 | 94.0 | 19.5 | 8.9 |
| 60 | 94 | 148 | 5 | 229 | 95.5 | 24.0 | 10.0 |
| 90 | 92 | 155 | 5 | 224 | 98.0 | 28.8 | 12.4 |
| 90 | 95 | 139 | 5 | 222 | 103.0 | 47.0 | 13.1 |
| Avg. | 93 | ... | . | ... | 96.3 | .... | .... |
| *Submerged Coil, Manifolded:* | | | | | | | |
| 60 | 88 | 153 | 2 | 219 | 96 | 11.9 | 5.8 |
| 60 | 90 | 160 | 2 | 219 | 94 | 11.5 | 6.5 |
| 60 | 90 | 162 | 3 | 222 | 96 | 12.9 | 7.7 |
| 60 | 90 | 159 | 4 | 225 | 96 | 16.3 | 8.5 |
| 60 | 90 | 149 | 5 | 228 | 96 | 23.2 | 9.1 |
| 60 | 91 | 145 | 7 | 233 | 99 | 29.5 | 9.2 |
| 60 | 90 | 132 | 6 | 230 | 102 | 34.8 | 9.8 |
| 60 | 92 | 134 | 8 | 235 | 102 | 37.5 | 10.0 |
| Avg. | 90.1 | ... | . | ... | 97.6 | .... | .... |
| *Cooling Tower:* | | | | | | | |
| 60 | 92 | 106 | 5 | 228 | 110 | 13.2 | 4.1 |
| 60 | 92 | 106 | 5 | 228 | 110 | 13.9 | 5.9 |
| 60 | 92 | 116 | 5 | 228 | 110 | 16.8 | 7.0 |
| 90 | 92 | 100 | 5 | 225 | 100 | 18.8 | 8.0 |
| 40 | 92 | 104 | 4 | 225 | 105 | 25.8 | 8.4 |
| 40 | 92 | 106 | 4 | 225 | 105 | 33.3 | 8.7 |
| 40 | 92 | 106 | 4 | 225 | 105 | 4.72 | 8.9 |
| Avg. | 92 | ... | . | ... | 106.4 | .... | .... |
| **Cooling-Water Flow Constant** | | | | | | | |
| *Double-Pipe Coil:* | | | | | | | |
| 30 | 92 | 230 | 50 | 298 | 115 | 23.8 | 31.5 |
| 30 | 92 | 221 | 40 | 287 | 105 | 21.6 | 24.1 |
| 30 | 92 | 212 | 30 | 274 | 98 | 21.7 | 20.3 |
| 30 | 92 | 190 | 20 | 259 | 95 | 21.6 | 16.3 |
| 30 | 92 | 188 | 15 | 250 | 94 | 21.4 | 13.4 |
| 30 | 92 | 160 | 8 | 235 | 94 | 21.5 | 10.5 |
| Avg. | 92 | ... | .. | ... | .... | 21.9 | .... |
| *Submerged Coil, Not Manifolded:* | | | | | | | |
| 60 | 96 | 120 | 5 | 224 | 96 | 21.2 | 2.4 |
| 60 | 96 | 141 | 5 | 224 | 97 | 21.1 | 5.6 |
| 60 | 94 | 156 | 5 | 227 | 98 | 21.6 | 8.8 |
| 60 | 93.5 | 166 | 5 | 224 | 99.5 | 20.9 | 10.8 |
| 60 | 92 | 172 | 5 | 224 | 100.5 | 20.7 | 12.6 |
| 60 | 92 | 172 | 5 | 223 | 105.0 | 21.7 | 14.1 |
| 40 | 91 | 192 | 18 | 255 | 110.0 | 20.0 | 14.8 |
| 40 | 92 | 192 | 20 | 259 | 122.0 | 20.2 | 16.2 |
| 40 | 91 | 200 | 22 | 262 | 137.0 | 21.4 | 19.8 |
| Avg. | 93 | ... | .. | ... | .... | 21.0 | .... |
| *Submerged Coil, Manifolded:* | | | | | | | |
| 60 | 88 | 122 | 1/4 | 213 | 93 | 20.0 | 3.7 |
| 60 | 88 | 125 | 1 | 216 | 95 | 20.3 | 4.5 |
| 60 | 90 | 130 | 2 | 219 | 97 | 20.3 | 5.3 |
| 60 | 90 | 142 | 4 | 225 | 101 | 20.0 | 6.8 |
| 60 | 92 | 161 | 7 | 233 | 108 | 20.3 | 10.1 |
| 60 | 89 | 171 | 8 | 235 | 111 | 20.2 | 11.0 |
| 60 | 89 | 160 | 9 | 237 | 117 | 21.1 | 11.9 |
| 60 | 92 | 151 | 10 | 240 | 146 | 20.5 | 13.0 |
| Avg. | 89.8 | ... | .... | ... | .... | 20.3 | .... |
| *Cooling Tower:* | | | | | | | |
| 90 | 94 | 94 | 5 | 225 | 86.7 | 17.7 | 1.7 |
| 90 | 93 | 99 | 5 | 226 | 94.8 | 19.3 | 3.6 |
| 60 | 93 | 94 | 5 | 226 | 90.0 | 19.0 | 3.0 |
| 90 | 88 | 98 | 5 | 227 | 96.0 | 14.2 | 5.7 |
| 90 | 89 | 100 | 5 | 227 | 108.0 | 14.4 | 8.2 |
| 60 | 92 | 122 | 5 | 224 | 120.0 | 18.3 | 10.5 |
| 60 | 92 | 125 | 5 | 225 | 125.0 | 20.4 | 12.1 |
| 90 | 93 | 118 | 5 | 218 | 131.5 | 18.1 | 15.6 |
| Avg. | 91.8 | ... | ... | ... | .... | 17.7 | .... |

## DESIGN OF STEAM POWER STATIONS FOR HYDRAULIC RELAY

(*Continued from page 652*)

Miscellaneous power service and lighting should, in general, be completely relayed against more than momentary interruption; for some classes of power, frequently that applied to electrolytic processes, for example, longer interruption of service is not of so serious moment, not sufficiently serious to warrant the expense of full relay; on the other hand, an extensive d.c. network, such as that in large metropolitan cities, must be absolutely safeguarded against interruption, however brief.

When the steam relay station is to serve as an instantaneously available reserve, the necessary excess capacity in generating units must be maintained on the line and actually under steam at all times. Station design to provide most economically for such service must afford, for minimum investment, a maximum of flexibility in capacity with minimum stand-by charges. Characteristics in equipment peculiarly favoring these requirements are:

1 Combination electric-steam drive on the larger auxiliaries, such as circulating pumps and mechanical-draft fans, for the units operated as floating stand-by
2 Turbo-generating units with direct-driven exciter, and with overspeed-controlled steam bypass for turbine-blade cooling independent of normal governing valves
3 High ratio of turbo-generator capacity in comparison with point of lowest water rate
4 Wide flexibility with quick response in control of boiler output and rate of combustion
5 High ratio in capacity of combustion equipment vs. area of boiler heating surface.

Where commercially available, fuel oil with mechanical atomization is particularly advantageous on this class of service, and its use permits the fulfilment of these boiler-plant requirements to an almost ideal degree. With proper design the response to control is practically instantaneous; capacity attainable is the highest of any commercial fuel. Oil fuel has the added advantage, particularly important in stand-by service, of minimum banking loss.

Pulverized coal, bituminous or sub-bituminous, for the larger plants, is only second to oil in flexibility of control and low banking loss. In general the underfeed type of mechanical stoker, given proper ratio of grate area to heating surface, will also fully meet the requirements in both flexibility and capacity, but banking losses are necessarily higher than for either oil or pulverized coal.

The class of fuel to be adopted in any particular case should be governed by the local conditions of fuel market, load and relay-station load factor, present and prospective, station location and capacity. However, it is usually true that fitness of equipment, and of its arrangement, for the requirements of the fuel determined upon, are more important than selection of type of fuel.

Emergency relay service on loads for which absolute continuity is of less vital importance will normally involve actual readiness to serve only during periods of anticipated power deficiency such as between seasons when stream flow is precariously near the actual load requirements and any slight diminution of flow will necessitate calling upon the relay station, or when there is possibility of sudden ice accumulation, or threatening floods.

For relay service of this character it will usually be sufficient to maintain a few boilers under fire and the larger of the essential auxiliaries turning over. The general characteristics of equipment outlined for conditions requiring instantaneous availability of the reserve apparatus will be advantageous in this case also. The combination electric-steam drive for auxiliaries may be omitted in the interest of first cost as the relay is not necessarily intended to meet full failure of hydraulic power, but the provision of electric drives for one complete set of essential auxiliaries, as recommended for the normal deficiency make-up of relay station to permit prompt starting of such equipment without waiting for steam, will usually be found particularly advantageous under the service conditions now considered. It may also under some conditions be advantageous to make use of electrical heaters in maintaining hot-water circulation in certain of the boilers, instead of actually holding them under fire. Oil is again the ideal fuel, but it is questionable if in the average case pulverized fuel will possess any advantage over the forced-draft underfeed stoker. New developments may, of course, readily change the relative status of these two methods of burning coal. In general the features of design which are specially advantageous for this type of relay are common to the instantaneous type of relay and are readily embodied in the station designed for the simpler type of make-up service.

Considering again the general characteristics and requirements of the steam relay station, the feature which should be regarded as secondary only to low construction cost and adequate dependability is that of low attendance requirements, and not merely for the non-operating period but for actual operation as well. With this object in view the design should tend to large units and, as far as compatible with thorough simplicity, to automatic control. Where feasible, combining the functions of distributing station with those of the hydraulic relay; assists materially in holding down both construction costs and attendance for the relay station. It should be borne in mind, however, that maximum returns on the investment in any type of steam power station can only be had through skilled and well-trained operators. Such men cannot be picked up on a moment's notice. It is true that it is often possible during periods of plentiful water supply to distribute men from the steam stations through other departments, but the number of men that may actually be employed in this way is limited. Where men are held over long periods without really effective employment, there is invariably loss of efficiency and of morale.

## DESIGN AND CONSTRUCTION OF 16-IN. DISAPPEARING CARRIAGE

(*Continued from page 660*)

machined to varying diameters so as to give a uniform pressure throughout the stroke. By means of these various hydraulic systems, the enormous weights move from one position to another without the least shock or perceptible vibration.

How closely the pressure in the recoil cylinders can be kept constant, the assumption made in the calculation, is illustrated by indicator-card records taken from the 16-in. disappearing carriage, model of 1912 (Fig. 5). The first diagram shows the operation of the recoil system during recoil. For the first five inches of recoil there is no pressure on account of the void left in the cylinder to take care of the expansion of the oil. The pressure quickly builds up to a maximum of about 1200 lb. per sq. in. and remains constant over the remainder of the length of recoil. The velocity curve shows that the maximum velocity of the top carriage of about 10 ft. per sec. is quickly reached and that this velocity is reduced almost on a straight line over the length of recoil. The time curve shows that the gun moved from the in-battery to the recoiled position in about two seconds. The velocity and time curves were obtained by means of velocimeters.

The second diagram shows the operation of the same system as the gun goes from the loading or recoiled position to the in-battery or firing position. There is no appreciable pressure in the recoil cylinder until the buffer mechanism, previously described, comes into play. This buffer acts for the last 16 in. of counter recoil. The pressure quickly builds up to about 3500 lb. per sq. in. and the velocity which has reached over 3.5 ft. per sec. is quickly reduced to zero. The time for the gun to move into battery is shown to be about seven seconds.

The third diagram shows the pressure in the hurter cylinders at the end of recoil. The orifices are proportional so that the pressures will remain nearly constant throughout the stroke.

The construction of the elevating arm may be of interest because by making this arm elastic the force which it must carry is reduced from about 4,000,000 lb. to less than 1,000,000 lb. When a suddenly applied load is brought upon this gun, the oil in the cylinder of its recoil mechanism is throttled past the piston head through two grooves of varying cross-section cut in the cylinder wall parallel to the longitudinal axis. The cross-sectional area of these grooves is such that a constant pressure is maintained in the cylinder throughout the stroke. The piston remains stationary while the cylinder moves. As soon as this heavy load is relieved, the springs force the arm to return to its original length, and the recoil mechanism again acts to prevent the sudden action of the springs.

# SURVEY OF ENGINEERING PROGRESS

## A Review of Attainment in Mechanical Engineering and Related Fields

# The Various Determinations of the Specific Heat of Steam and Their Technical Significance

By H. Schmolke

In the past few years several attempts have been made to determine the specific heat $c_p$ of superheated steam at constant pressure for a wide range of temperatures and pressures. This is of great practical importance since $c_p$ is one of the most valuable physical magnitudes, and in so far as its relation to pressure and temperature is known, it makes possible the determination of all the other thermodynamic properties of steam, as has been shown by Planck. Thus, if $u$ denotes the internal energy of steam, $v$ its specific volume, $p$ its specific pressure and $A$ the heat equivalent, then the heat content of steam is found to be $i = u + Apv$, this being obtained by means of the equation—

$$c_p = \left(\frac{\partial i}{\partial T}\right)_p$$

in which $T$ denotes temperature, and $i$ can be determined provided $c_p$ has been found by measurement. Further, the entropy $s$ can be determined from the equation—

$$c_p = T\left(\frac{\partial s}{\partial T}\right)_p$$

if the specific heat of the steam is known for all values of $p$ and $T$. This makes it possible to determine from experimental data the function—

$$\varphi = s - \frac{i}{T}$$

and from this can be determined all the magnitudes defining the state of steam, since if the above value for $i$ is introduced into the function for $\varphi$, the following equation is obtained:

$$d\varphi = ds - \frac{du + Apdv + Avdp}{T} + \frac{u + Apv}{T^2}\,dT \;\ldots\ldots [1]$$

Also since

$$ds = \frac{du + Apdv}{T}$$

another expression for the same function is obtained, namely:

$$d\varphi = -A\,\frac{v}{T}\,dp + \frac{u + Apv}{T^2}\,dT \;\ldots\ldots [2]$$

but in accordance with general rules of mathematics the total differential must be—

$$d\varphi = \left(\frac{\partial\varphi}{\partial p}\right)_T dp + \left(\frac{\partial\varphi}{\partial T}\right)_p dT \;\ldots\ldots [3]$$

and likewise

$$\left(\frac{\partial\varphi}{\partial p}\right)_T = -A\,\frac{v}{T},\ \text{and}\ \left(\frac{\partial\varphi}{\partial T}\right)_p = \frac{u + Apv}{T^2} = \frac{i}{T^2} \;\ldots [4]$$

From this it follows that

$$Av = -T\left(\frac{\partial\varphi}{\partial p}\right)_T;\ i = T^2\left(\frac{\partial\varphi}{\partial T}\right)_p;\ s = \varphi + T\left(\frac{\partial\varphi}{\partial T}\right)_p \;\ldots [5]$$

and

$$u = T\left[T\left(\frac{\partial\varphi}{\partial T}\right)_p + p\left(\frac{\partial\varphi}{\partial p}\right)_T\right] \;\ldots\ldots [6]$$

By partial differentiation of $\varphi$ with respect to either $p$ or $T$ all the fundamental magnitudes of steam can be found, and because of this $\varphi$ is called the characteristic function of steam.

This is of importance not only for the superheat range of steam, but has a certain significance for the range of saturation, as it may be shown that at the limit of saturation the characteristic function has the same value for both steam and water. If superheated steam and water are brought into contact under conditions where all outside influences are excluded, then at each change of state the volume $V$, the internal energy $U$, and the mass $M$ of the entire system must remain constant, and hence $\delta M = 0$, $\delta V = 0$, and $\delta U = 0$. The notation $\delta$ indicates a virtual, infinitely small variation of state, while $d$ corresponds to an actual process. Since $M = M_1 + M_2$ (where subscript 1 refers to steam and subscript 2 to water), and similarly one may write $V = M_1v_1 + M_2v_2$ and $U = M_1u_1 + M_2u_2$, it is advisable to express the above equations of condition in the form—

$$\Sigma\delta M_n = 0,\ \Sigma M_n\delta v_n + \Sigma v_n\delta M_n = 0,\ \text{and}\ \Sigma M_n\delta u_n + \Sigma u_n\delta M_n = 0 \;\ldots [7]$$

Here $\Sigma$ denotes the summation of the magnitudes indicated by subscript 1 and subscript 2. If, in the system under consideration, equilibrium prevails, the entropy is a maximum and therefore its variable $\delta S = \Sigma M_n\delta s_n + \Sigma s_n\delta M_n$ is zero. Since, further, as has been shown above, one may write—

$$\delta s = \frac{\delta u + Apdv}{T}$$

it follows that

$$\delta S = \Sigma\,\frac{M_n\delta u_n}{T_n} + A\Sigma\,\frac{M_np_n\delta v_n}{T_n} + \Sigma s_n\delta M_n = 0 \;\ldots\ldots [8]$$

From the three equations of condition of state, expressions may be found for $\delta M_2$, $\delta v_2$ and $\delta u_2$. These expressions are introduced into Equation [8] for $\delta S$, which gives

$$\delta S = \left(\frac{1}{T_1} - \frac{1}{T_2}\right)M_1\delta u_1 + A\left(\frac{p_1}{T_1} - \frac{p_2}{T_2}\right)M_1\delta v_1 + \left(s_1 - s_2 - \frac{u_1 - u_2}{T_2} - \frac{Ap_2\,(v_1 - v_2)}{T_2}\right)\delta M_1 = 0 \;\ldots\ldots [9]$$

The three variables $\delta u_1$, $\delta v_1$ and $\delta M_1$ appearing here are entirely independent of each other and therefore in order that $\delta S$ shall become zero for all changes of state, it becomes necessary that each of the three coefficients become zero; for this to take place it is necessary that $T_1 = T_2 = T$, and $p_1 = p_2 = p$, and—

$$s_1 - s_2 = \frac{u_1 - u_2 + Ap(v_1 - v_2)}{T},\ \text{or}\ s_1 - \frac{u_1 + Ap_1v_1}{T_1} = s_2 - \frac{u_2 + Ap_2v_2}{T_2} \;\ldots\ldots [10]$$

This proves that in the state of equilibrium the characteristic functions of steam and water are equal to each other. But the former, as has been shown above, may be expressed as a function of $p$ and $T$ providing $c_p$ has been determined by measurement.

For example, Dieterici found that the specific heat of water is $c_{fl} = a - bT + cT^2$, where $a$, $b$ and $c$ are constants. From this it would appear that the entropy of the liquid is

$$s' = \int\frac{c_{fl}\,dT}{T}$$

and its heat content at the limit of saturation is

$$i' = \int c_{fl}\,dT + Apv_0.$$

Since $v_0$, the specific volume of water at 0 deg. cent., is known, the characteristic function $\varphi' = s' - i'$ may be computed and set down as being equal to the corresponding characteristic function of pure steam. This in its turn makes it possible to determine the saturation pressure and the heat of evaporation, provided, however, the specific heat of the steam has been correctly determined by measurement, which once more proves the great thermodynamic value of a correct knowledge of the specific heats of steam.

Prior to 1906 only very meager information was available as to the numerical relation between the specific heat of steam and pressure and temperature variations. Regnault was one of the first investigators to take the trouble to determine experimentally the specific heat of steam at atmospheric pressure and a temperature of about 175 deg. cent. (347 deg. fahr.), and he found that at these conditions $c_p = 0.48$. For a while this value was accepted not only as the average value within the temperature range of 128 to 221 deg. cent. (262.4 to 429.8 deg. fahr.), but a further step was taken and an erroneous conclusion drawn from Regnault's observations to the effect that $c_p$ is generally independent of $T$.

R. Mollier accepted this assumption as a basis in working out his *J-S* diagram for steam, first published in 1904, and which had since become of great practical importance. He did this notwithstanding the fact that experiments carried out considerably earlier than the publication of his papers by Mallard and LeChatelier have given sufficient information to indicate the incorrectness of the above assumption. Although these two investigators clearly established that the numerical value of $c_p$ increases in the higher ranges of temperature, nevertheless the belief in the invariability of the specific heat of steam continued to prevail and variations were admitted only within the highest ranges of temperature. As to the dependence of $c_p$ on pressure, no information whatsoever appears to have been available at that time (1904). An important step in advance was made with the publication of the investigations of R. Linde and H. Lorenz in 1905. The former numerically calculated the specific heat $c_p$ from the experimentally determined value of specific volume $v$ and found that this decreased with increase of temperature and increased with increase of pressure. Lorenz came to the same conclusion from an investigation of specific heat by direct measurement, and at about the same time Callendar arrived at similar conclusions which compelled Mollier to revise his recently published diagram.

While the above investigations brought about a change of view as to the functional relation, if any, between the specific heat of steam on one hand, and temperature and pressure on the other, they did not solve the problem of the quantitative character of this relationship, and it was the work carried out at the Laboratory of Engineering Physics in the Munich High School by O. Knoblauch and M. Jakob that gave the first reliable figures (1906).

In the original experimental installation as used in Munich, the steam from the boiler went first into a water separator where dewatering was accomplished by mechanical means and thence passed into an electric superheater, in which latter the steam, after thorough drying, was raised to a temperature of $t_1$ deg. cent. Then in a second superheater the temperature was raised to $t_2$ deg. cent. by supplying the steam with a precisely measured amount of electrical heat energy equal to $W$ cal. per hr. Thereupon the steam was condensed in two condensers and its weight $G$ kg. per hr. was determined.

In order to compute the average specific heat within the temperature range of $t_1$ to $t_2$ from the data of measurement, employment was made of the formula—

$$c_p = \frac{W - V}{G\,(t_2 - t_1)}$$

where $V$ is the unavoidable heat loss determined by separate tests.

The experiments were carried out over a pressure range of 2 to 8 atmos. and with temperatures ranging from around saturation to 350 deg. cent. (662 deg. fahr.). On the whole they led to the following conclusions: $c_p$, with temperature $T$ constant, increases within increase of pressure, especially in the region near saturation; with the pressure constant $c_p$ decreases with increase of temperature, reaches a certain minimum value, and then with increase of superheat begins to increase. The specific heat at 0 atmos. pressure is not constant, but rises with increase of temperature.

It would appear from this that the general conclusions arrived at at Munich, notwithstanding the presence of quantitative differences, are in the main in accord with former observations. These observations were further extended by the publication in 1911 of the investigations by Knoblauch and Hilde Mollier bearing on the specific heat of steam at pressures from 2 to 8 atmos. and temperatures of 350 to 550 deg. cent. (662 to 1022 deg. fahr.).

In these tests, also carried out in Munich, the boiler steam was dried in a gas-heated preheater and after it attained a temperature of $t_1$ deg. it was led into an electric superheater which constituted the real experimental unit. Here its temperature was raised to $t_2$ deg. cent. by the addition of an amount of heat energy $W$, and the steam was then condensed in a condenser. After weighing the condensate and determining the heat losses by a separate test, it became possible to compute the specific heat by the formula above referred to. The new tests have confirmed the increase in $c_p$ with increasing pressure, likewise its initial falling off with rising temperature and the existence of a minimum. It was also found that within the limits of temperature of 350 to 550 deg. cent. (662 to 1022 deg. fahr.) the increase in specific heat with increase in pressure became constantly smaller, so that ultimately the difference of values of $c_p$ at equal temperatures and various pressures could barely be determined. The increase in specific heat with increase in superheat was observable also in the above range.

The minimum value attained by $c_p$ with increase in temperature and determined by the Munich experimenters was confirmed later by the important investigations of L. Holborn and F. Henning, who worked with atmospheric pressure and temperatures up to 1350 deg. cent. (2462 deg. fahr.).

Investigations at such high temperatures appear, however, to have a theoretical rather than a practical interest. Of greater engineering importance are the determinations published in 1917 from work carried on again in Munich by O. Knoblauch and A. Winkhaus concerning the specific heat at pressures of from 8 to 20 atmos. and temperatures from the limit of saturation to 380 deg. cent. (716 deg. fahr.). In these tests the experimental installation already described was used, and $c_p$ was computed in the same manner as before. It was found that there is also an increase of specific heat with increase in pressure in the new range of high pressures. As compared with the data of tests made in 1911 there were found slight variations in the region near saturation. There the numerical values of $c_p$ were shown by the new investigation to be somewhat lower than the previous investigation would indicate, the new values being closer in accordance with the values of Holborn and Henning. Although the tests at Munich were carried on to pressures up to 30 atmos., it may be said that dating from the appearance of the investigation by Knoblauch and Winkhaus $c_p$ may be considered as definitely known within the ranges used in ordinary engineering. It is also claimed that the theory for making use of the experimental observations has also been carried to a full practical conclusion, and that such a conclusion was reached when it became possible to derive by calculation all the magnitudes of the state of steam from data obtained by measurement.

At the same time, however, the analytical work of deriving one of the magnitudes defining the state of steam from another is by no means easy. This was found when an attempt was made to derive the specific heat $c_p$ from an equation found experimentally by R. Linde for the specific volume of steam, namely,

$$v = \frac{RT}{p} - (1 + ap) \times \left[ C\left(\frac{373}{T}\right)^3 - D \right] \ldots\ldots [11]$$

in which $R$ is the gas constant (47.1), and $a$, $C$ and $D$ are constants. Notwithstanding the fact that the above equation expressed with the greatest possible precision experimentally observed data, and the further fact that there is available for determining $c_p$ from $v$ the relation—

$$\left(\frac{\partial c_p}{\partial p}\right)_T = -AT\left(\frac{\partial^2 v}{\partial T^2}\right)_p \ldots\ldots\ldots\ldots [12]$$

derived by Clausius, the computation led to results which quantitatively could not be brought into accord with data found by actual measurement. The same happens when use is made of

the modified equation for specific volume proposed by Callendar, or the modification of the Linde formula given by Goodenough.

The reason for this was indicated in 1912 by Jakob. From the Clausius equation it follows directly that—

$$c_p = c_p{}^0 - AT \int_0^p \left(\frac{\partial^2 v}{\partial T^2}\right)_p dp \qquad [13]$$

when $c_p{}^0$ is the value of specific heat in the ideal gaseous state. Because of this, in order to obtain $c_p$ from $v$, it becomes necessary to carry through a double differentiation of the equation for the specific volume. This latter, written in a simplified manner, has the form

$$v = \frac{RT}{p} - \Delta v$$

where $\Delta v$ is a correction term expressing a deviation from the law of gases. Hence

$$\left(\frac{\partial^2 v}{\partial T^2}\right)_p = -\left(\frac{\partial^2 \Delta v}{\partial T^2}\right)_p \text{or } c_p = c_p{}^0 + AT \int_0^p \left(\frac{\partial^2 \Delta v}{\partial T^2}\right)_p dp \qquad [14]$$

From this it would appear that the determination of $c_p$ depends primarily on the uncertain correction term in the equation of state and the double differentiation of the latter may easily lead to error. It is easy to understand why the failure of previous attempts created an impression that it would be generally impossible to establish a satisfactory connection between $v$ and $c_p$ on the basis of the Clausius equation. Jakob disproved this view by deriving from specific heats specific volumes by means of a system of $c_p$ isobars in the $c_p$-$t$ diagram. He did this graphically by using the relation—

$$v = \frac{RT}{p} - \frac{1}{A}\int_{T_0}^{T}\int_{T_0}^{T}\frac{1}{T}\left(\frac{\partial c_p}{\partial p}\right)_T dT^2 \qquad [15]$$

which is derived from the Clausius equation and in which $T_0$ is the temperature of the ideal state of gas.

Jakob, however, also considered as hopeless all exclusively analytical attempts at solving this problem, and it was only in 1916 that R. Planck succeeded in deriving an expression for the shape of the $c_p$ isobars, which, on one hand reproduces with sufficient precision the experimental data, and on the other hand, permits that double integration which is necessary in order to determine $v$ from $c_p$, as would appear from the above equation. In this he was successful, which means that the values of specific volume analytically found by him were in sufficient accord with the volumes determined by actual measurement. Unfortunately, however, his work is of greater value from the point of view of mathematics than of practical engineering, because his equation of state is of such a complicated form as to make its use in engineering impossible. Complete success in this field was attained only in 1920 by G. Eichelberg, who gave to the $c_p$ isobars an expression of very high precision:

$$c_p = c_p{}^0 + \frac{C_1 p}{T^4} + \frac{C_2(p + 2 \times 10^4)^{3.2} - C_3}{T^{15}} \qquad [16]$$

where $C_1$, $C_2$ and $C_3$ are constants. From this it follows that—

$$\left(\frac{\partial c_p}{\partial p}\right)_T = \frac{C_1}{T^4} + \frac{3.2C_2(p + 2 \times 10^4)^{2.2}}{T^{15}} \qquad [17]$$

If this is inserted in the Clausius equation we obtain—

$$A\left(\frac{\partial^2 v}{\partial T^2}\right)_p = -\frac{C_1}{T^5} - \frac{3.2C_2 \times (p + 2 \times 10^4)^{2.2}}{T^{16}} \qquad [18]$$

and by double integration with respect to $T$ we have—

$$Av = \psi(p) + T\varphi(p) - \frac{C_1}{3 \times 4\, T^3} - \frac{3.2C_2(p + 2 \times 10^4)^{2.2}}{14 \times 15 \times T^{14}} \qquad [19]$$

The undetermined functions $\psi(p)$ and $\varphi(p)$ necessary for the solution of the partial differential equation can be taken care of by the assumption that when temperature $T$ rises, the values of specific volumes approach asymptotically those of the ideal gas. If this be so, then

$$T = \infty,\ v = \frac{RT}{p}, \text{ and } \left(\frac{\partial v}{\partial T}\right)_p = \frac{R}{p}.$$

Hence $\partial(\varphi) = \dfrac{AR}{p}$ and $\psi(p) = 0$.

By inserting these values in Equation [19], an equation of state is found giving values of specific volumes in every respect in accord with those derived experimentally. The correction member of this equation has the form $f(p, T,)$ while that of the equations of Linde, Callendar and Goodenough has the form $f(p)g(T)$, and it is this latter form that has been cited by Jakob as the main reason for previous failures to derive analytically $c_p$ from $v$. Jakob's objections do not hold against Eichelberg's formula and its comparatively simple structure appears to make it suitable for practical purposes. Thus by this means one can compute without much trouble the entropy $s$ and the heat content $i$ from the generally known thermodynamic equations—

$$di = c_p dT - A\left[T\left(\frac{\partial v}{\partial T}\right)_p - v\right]dp \qquad [20]$$

and

$$ds = \frac{c_p}{T}dT - A\left(\frac{\partial v}{\partial p}\right)_T dp \qquad [21]$$

Then again with expressions for $i$ and $s$ available, the preparation of entropy tables becomes very much simplified through the elimination of the time-consuming planimetering of $c_p$- and $c_p/T$-curves. Furthermore, the Eichelberg equation makes it possible to determine analytically the exponents of the adiabatics of superheated steam, so that on the whole this equation may be considered as the keystone of a notable series of important investigations in a field of scientific and engineering importance. (*Zeitschrift f. Dampfkessel und Maschinenbetrieb*, vol. 44, nos. 1 and 2, Jan. 7 and 14, 1921, pp. 3–4 and 12–13, *pA*)

# Improved Methods of Fatigue Testing

By H. J. GOUGH

REPORT submitted in April of this year by the author, member of the Engineering Department of the National Physical Laboratory, to the Materials and Chemistry Committee of the Aeronautical Research Committee, and published in advance of its official appearance.

The machine used in these tests is shown in Fig. 1 with some slight changes dealing chiefly with the lubrication arrangements and method of drive.

*SccS* is the central crankshaft with a heavy flywheel *F*. It is driven by a direct-coupled electric motor—not shown. The throw, or double radius, of each crank is 1 in. Two connecting rods *KK* join the rotating cranks *cc* to the balanced rocking arms *CC*, whose radii are 4 in. The shafts of the rocking arms end in clutches *QQ*, and the spindles of the two oscillating masses *WW* have similar clutches into which the ends of the test pieces *TT* can be secured. The oscillating masses *WW* are built up of a number of circular disks, the polar moments of inertia of which are known.

The original article shows the method of calculating stresses in specimens under test and the forms of test pieces—hollow and solid. It is obvious from the description of the machine that the fatigue on the material was induce by the action of the unbalanced flywheels.

Several methods of determining the torsional fatigue limit were considered, namely: (1) The rate of increase of strain with stress; (2) the rate of increase of width of the hysteresis loop with stress; and (3) the rate of increase of temperature due to internal work with stress. Methods 1 and 3 were those chiefly used. The specimen was placed in the holders and the machine run at low speed. The speed of the machine was hand-controlled throughout the test. When the galvanometer reading had become steady, it and the

strain-scale reading were taken. The speed was then increased by increments of 10 r.p.m., both scales being read at each speed. At a certain speed dependent upon the material, the amplitude of the motion of the spot suddenly increased. In most cases this increase was quite sudden and definite, the band of light opening out at both ends. In some cases the galvanometer mirror also swung across at the same time. Sometimes, however, this effect happened at a slightly higher speed and the yield point was seldom shown as clearly by the thermocouple as by the strain scale.

The material chiefly experimented on was 0.65 per cent carbon steel. The scale readings for both the thermocouple and strain

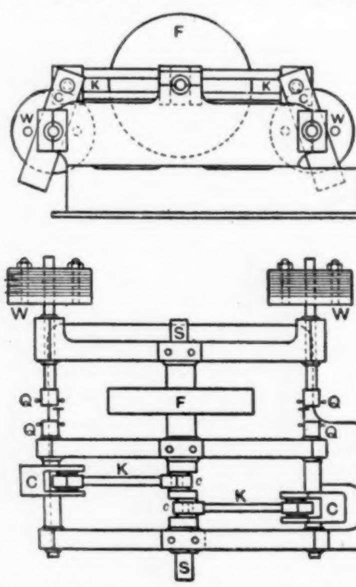



Fig. 1 Stromeyer's Machine for Measuring Alternating Torsion

scale are plotted against speed of machine in Figs. 2 and 3. The very definite nature of the yields is shown clearly by the curves. The "yield" point incurred at stresses of ±10.2 and ±10.5 tons per sq. in. for the solid and hollow test pieces, respectively. The difference may safely be ascribed to slight differences between the actual specimens tested. The thermocouple curve for the hollow specimen indicates the same "yield" point as the strain or deflection curve. With the solid specimen, however, the thermocouple curve gives the breakdown as occurring at a slightly higher speed than that given by the deflection curve. This difference is highly important as affecting the calculated stress at which breakdown occurs.

Reference to the formula from which the stress is calculated—

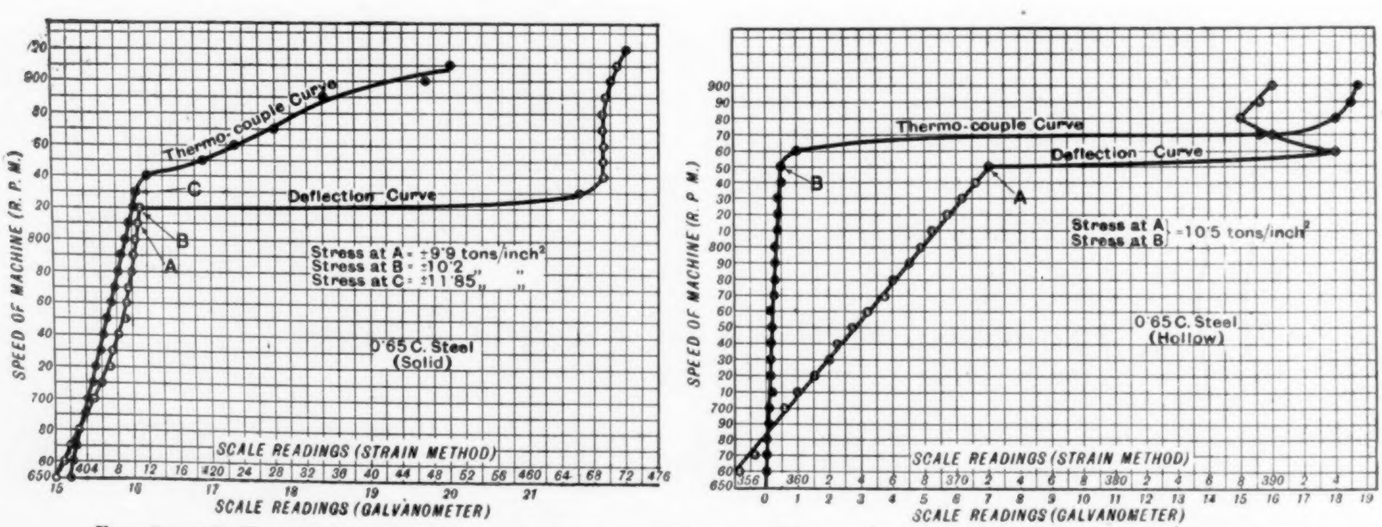
$$f_s = \pm KM\theta n^2/I$$

shows that the stress is proportional to the amplitude of the oscillating mass. In Fig. 2 the calculated stresses at the points $A$, $B$ and $C$ are as follows: Stress at $A$ = ±9.9 tons per sq. in.; stress at $B$ = ±10.2 tons per sq. in.; stress at $C$ = ± 11.85 tons per sq. in.

Considerable error is involved if the yield point is assumed to be (from the thermocouple curve) at $C$ instead of at $B$ (from the strain curve). In several other tests a similar "lag" was noted on the thermocouple curve.

To show this point more clearly, Figs. 2 and 3 have been replotted to "stress" ordinates—see Figs. 4 and 5. That the fatigue limit is masked by the thermocouple in the case of the solid specimen may have been due to the following causes: (1) The galvanometer used may not have been sufficiently sensitive; (2) owing to the larger heat capacity of the solid specimen, the lag of the thermocouple may be a time effect. In some further experiments now being carried out, a galvanometer of much greater sensitiveness is being employed. Also a longer time interval is allowed before the galvanometer is read. With these precautions the thermocouple indicates the fatigue range at a stress in agreement with that given by the yield method. The change of slope of the stress-temperature curve is, however, nearly always less than that of the stress-strain curve. This fact would lead to the inference that if the calorimetric method of determining fatigue limits were used in a machine in which the stress applied was independent of the strain—the usual type of testing machine—it would be extremely difficult to estimate the stress at which the slope of the stress-temperature curve changed.

There is no doubt that the success of the yield and calorimetric methods described in this paper are due to the state of instability of the specimen under test, owing to the character of the machine employed. Directly a yield in the specimen occurs, the stress is automatically increased, producing a greater yield, and this multiplying effect continues until a second state of equilibrium of partial stability occurs. Careful deflection readings must obviously be taken in order to calculate the fatigue limit as shown by the thermocouple curve. Three observers are necessary for a calorimetric determination, whereas only two are required for the strain method. These facts lead to the conclusion that the strain method is more accurate and practical, although the calorimetric method is useful as a check.




Figs. 2 and 3 Thermocouple and Deflection Curves for Solid and Hollow Specimens of 0.65 per cent Carbon Steel

From these tests on 0.65 per cent carbon steel, the following conclusions were drawn: (1) That the fatigue limit under reversed shear stresses is marked by a "breakdown" or "yield" point in the material, as in Smith's experiments with direct stresses; (2) that this breakdown point is independent of the form of the section, solid or hollow; (3) that Guest's law applies to fatigue stresses. It can then be seen that these results and conclusions confirm those obtained by Dr. J. H. Smith for alternating direct stresses.

A curious phenomena was observed in the case of nickel, Fig. 6.

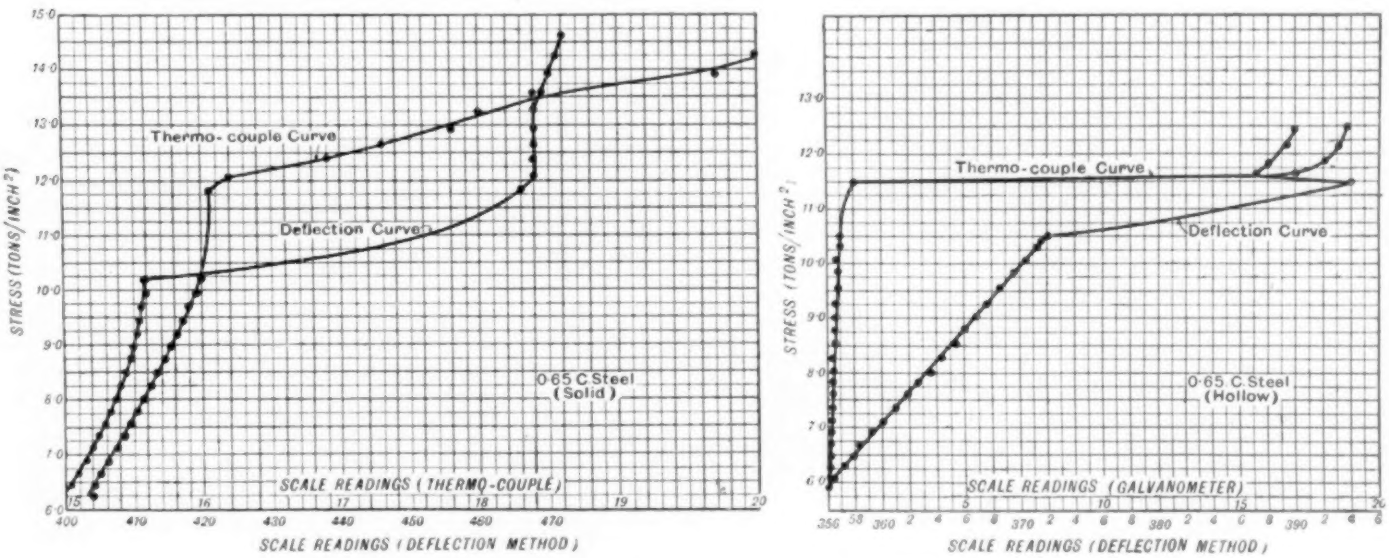
The material definitely yielded and again recovered. This is the only material which has, so far, behaved in this way.

Fig. 7 shows the results of the test on Swedish iron. The material was apparently very unstable up to a certain speed (500 r.p.m.). For the next two increments of speed the strains increased regularly, followed by a definite yield. Subsequently the strains again increased in a regular manner. This result was so unexpected that a second specimen of the same material was prepared. The mass of oscillating weight was reduced so that the breakdown would occur at a higher speed. The curve obtained was very similar to the first. Whether the peculiar shape of the first part of the curve is due to a change in the modulus of rigidity as the stress increases, it is as yet impossible to say.

The following possible, quick method suggested itself for determining the fatigue limit. If the load were increased by increments and the deflection of the end of the cantilever observed, then a deflection-load diagram would probably indicate a "breakdown" point at the fatigue limit. Owing to the fact that the maximum stress occurs only at the one section, the "breakdown" would probably be visible as an "elastic limit" effect rather than as a "yield" effect as in torsion.

A plane mirror was affixed to the non-rotating ball cage and the deflection magnified optically. At each load the image of the filament on the scale was read. It was necessary, owing to the weights employed, to remove the load altogether at four points, with the result that the ball cage fell slightly. The curve at these points was consequently discontinuous, but for the specimen used, the 0.65 per cent carbon steel (as used in the torsion experiments), a departure from the straight-line law was clearly indicated at a point corresponding to a stress of $\pm 20.74$ tons per sq. in. The endurance tests, it will be recalled, had given the fatigue limiting stress as $\pm 21.0$ tons per sq. in.

The experiment seemed to indicate that the method would prove an extremely quick and reliable one for determining the fatigue limit under reversed bending stresses. The apparatus was accordingly modified so that the load could be applied continuously. The mirror was mounted on the specimen and allowed to rotate with it. Fig. 8 shows the new arrangement. A 150-lb. capacity single-lever weighing machine was mounted on top of the Wöhler machine and the load applied by means of an adjustable rod and a stirrup on the outer ball race. Details of the mirror attachment are indicated in the illustration.




Figs. 4 and 5 Curves of Figs. 2 and 3 Replotted to Stress Ordinates

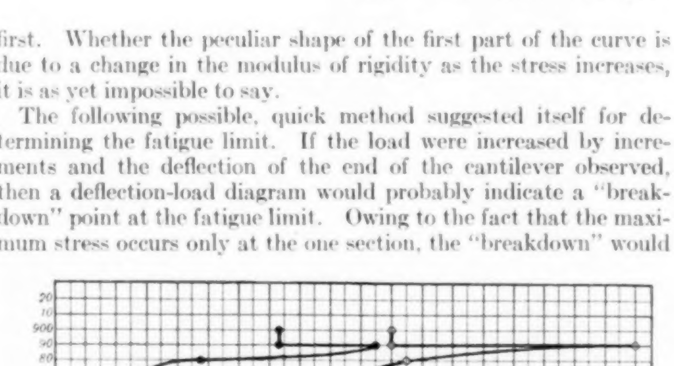



Fig. 6 Thermocouple and Deflection Curve for Solid Specimen of Pure Nickel

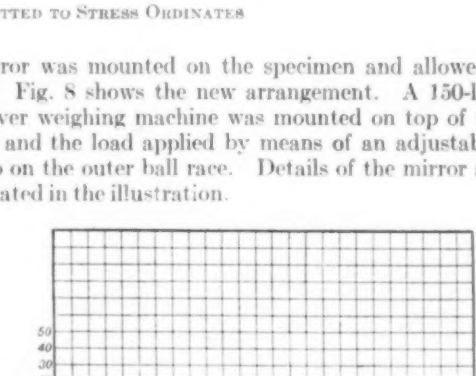



Fig. 7 Deflection Curve for Solid Specimen of Swedish Iron

Four materials have been experimented on using the modified apparatus: 0.65 per cent carbon steel (as used in the torsion tests); pure nickel (as used in the torsion test); a phosphor bronze (ultimate stress 36 tons per sq. in.); and a case-hardening steel. The observations taken from the 0.65 per cent carbon steel are shown plotted in Fig. 9. The other materials gave curves of the same type. The scale readings increase directly with the load until

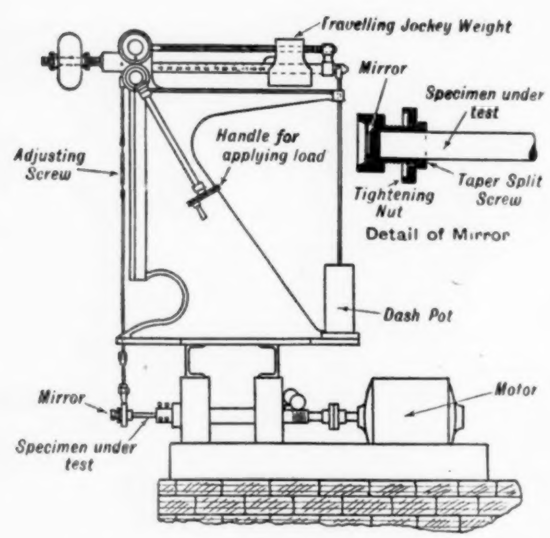



Fig. 8 Modification of Machine Shown in Fig. 1 Adapted for Quick Determination of Fatigue Limit Under Reversed Bending Stresses

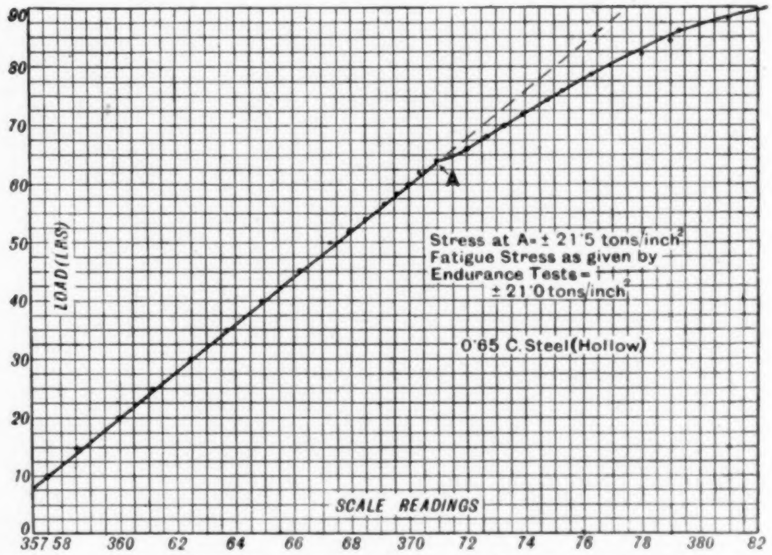



Fig. 9 Deflection Curve for Hollow Specimens of 0.65 per cent Carbon Steel Under Reversed Bending Stress

a certain stress is reached. Here a slight yield occurs. Subsequently the scale readings increase at an increasingly quicker rate than the load.

The stress at which the yield occurs coincides approximately with the limiting fatigue stress as found by the endurance tests.

The fatigue limiting stresses of nickel and the case-hardening steel as found by this new method on a solid specimen agree with the limiting stresses as found by endurance tests on hollow specimens. This fact indicates that the results obtained by this method are independent of the form of specimen used, a very important point, as the cost and difficulty of machining hollow specimens are rendered unnecessary. Table 1 compares the results obtained on the single specimens with those obtained by endurance tests.

TABLE 1 RESULTS OBTAINED ON VARIOUS METALS IN MEASURING FATIGUE LIMIT UNDER REVERSED BENDING STRESSES

| Material | Fatigue limiting stress under reversed bending stresses: By deflection method on a single specimen, tons per sq. in. | By endurance tests on six specimens, tons per sq. in. |
|---|---|---|
| 0.65 per cent carbon steel | ±21.5 | ±21.0 |
| Pure nickel | ±13.26 | ±13.2 |
| Phosphor bronze | ±17.2 | ±17.8 |
| Case-hardening steel | ±33.6 | ±32 to ±35 |

Six specimens of each material are usually used in the endurance tests. (*The Engineer*, vol. 132, no. 3424, Aug. 12, 1921, pp. 159–162, 13 figs. and 4 tables, *eA*)

# Short Abstracts of the Month

## CORROSION (See Power-Plant Engineering)

## ENGINEERING MATERIALS

Investigation of Physical Properties of Metals at High Temperatures Preceding Their Interval of Plasticity. Data of an investigation carried out under the direction of Professor Cantone in the Laboratory of Experimental Physics of the University of Naples. The investigation carried out by Dr. Mary Kahanoviez has been published in the Proceedings of the Accademia dei Lincei and deals mainly with the question of the transformations which occur in metals as a result of various heat processes. These were deduced from the emission of radiant energy from the metal. It was found that metals follow a simple law of emission which may be expressed by an equation of the type $E = kT^n$, where $E$ is the energy emitted at the given absolute temperature $T$, and $k$ and $n$ are characteristic constants of the given body. The law of emissivity for oxides of metals is expressed by a more complicated function.

As regards the transformations found, it appears that they differ from oxidations in that they take place with absorption of heat, are reversible and tend in general to make the metal more specular. With nickel, the transformation takes place at between 350 and 370 deg. cent. (662 and 698 deg. fahr), while with iron the point is found around 739 deg. cent. (1346 deg. fahr.). Of particular interest is the case of silver, where the transformation takes place around 770 deg. cent. (1418 deg. fahr.) and has not been discovered by any other method.

The investigation by Dr. Washington Del Regno deals with residual variations in electrical resistance produced as result of heat processes in nickel steels. (*Il Forno Elettrico*, vol. 3, no. 5, May 15, 1921, pp. 71–73, *g*)

### Mechanical Properties of Steel at High Temperatures

Universal Steel Classification Code. Horace C. Knerr and Arthur L. Collins. The present system of steel classification known as the S.A.E. system, is believed to be limited in scope and arbitrary rather than scientific.

Nine years ago when the system was inaugurated, alloys were few and the system did not provide for an indefinite expansion in that direction to meet present and future need.

The system was based on the use of numerals, which does not easily permit of expansion. Because of these and some other considerations, a new system was proposed in which letters in addition to numerals were employed, the letter system having the advantage that (omitting O and I) there are 24 available units as compared to nine with numbers. A letter is therefore chosen to represent, or at least suggest, the name of the material in question and numerals are used solely to indicate the quantities. In this way the alloy is expressed in a form somewhat similar to a chemical formula. The only question is whether such a system can be made sufficiently simple to meet practical requirements. The authors claim that it does.

To show how such a system works as compared with the present S.A.E. system the following examples may be cited:

Nickel Steels ("N" Steels)

| Proposed | Present |
|---|---|
| 20N1 | 2120 (1 per cent nickel, 0.20 per cent carbon) |
| 20N2 | 2220 (2 per cent nickel, 0.20 per cent carbon) |
| 35N3 | 2335 (3.50 per cent nickel, 0.35 per cent carbon) |

Nickel-Chrome Steels ("NK" Steels)

| Proposed | Present |
|---|---|
| 20N1K | 3120 (1.25 per cent Ni, 0.60 per cent Cr) |
| 30N2K1 | 3230 (1.75 per cent Ni, 1.10 per cent Cr) |
| 40N3K2 | 3340 (3.50 per cent Ni, 1.50 per cent Cr) |
| 35N3KX | X3335 (3.00 per cent Ni, 0.80 per cent Cr) |

(*The Iron Age*, vol. 108, no. 9, Sept. 1, 1921, pp. 515–517, *p*)

### Steel at High Temperatures

Experimental Investigation of the Mechanical Properties of Steel at High Temperatures, Eugene Dupuy. After a brief historical introduction the author comes to the conclusion that what previous work has shown is that steel at around 300 to 400 deg. cent. (572 to 752 deg. fahr.) exhibits a "blue brittleness," the characteristic of which is that the breaking load is higher and the reduction of area is at a minimum, above which temperature the breaking load gradually falls off and a greater reduction of area is observed reaching its maximum at around 1000 to 1300 deg. cent. (1832 to 2372 deg. fahr.)

An investigation by Rosenhain and Humphrey in 1913 appears to show that the curve indicating the relation between the temperature of the metal and the breaking load has two points of discontinuity which are perfectly well established and a third one which is doubtful.

The present author carried out a series of tests on plain carbon steel with the carbon content varying from 0.15 to 1.23 per cent both in its original state and heat-treated. From these it would appear that as the temperature increases, the breaking load begins to fall off. It is at a maximum of 300 deg. cent. (572 deg. fahr.), or in the region of "blue heat," and from then on it begins to fall

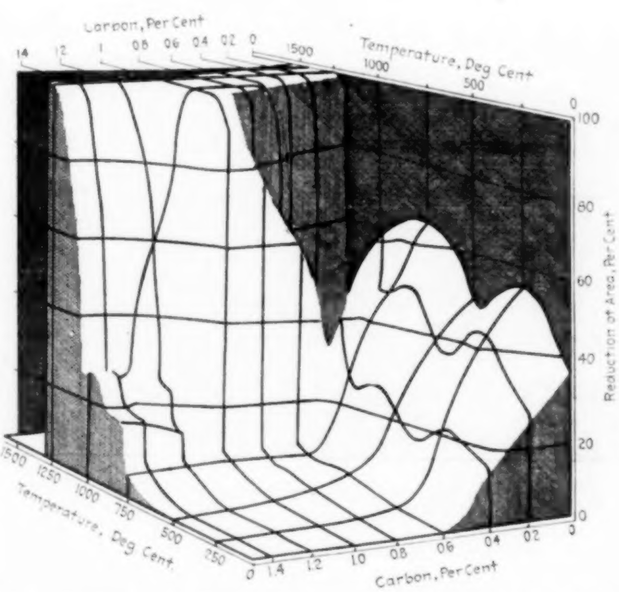



Fig. 1 Temperature-Carbon Content-Reduction of Area Curves for Non-Heat-Treated Ingot Steel

off, showing, however, a slight irregularity from about 450 to 550 deg. cent. (842 to 1022 deg. fahr.) up to a little below 750 deg. cent. (1382 deg. fahr.), the curve in this region having a shape somewhat like the letter U. Thereafter the breaking load decreases again up to the point where liquidus appears and the breaking load suddenly falls to zero. The U characteristic of the curves appears, however, only in hypoeutectoid steels and is absent in eutectoid steels.

These various phenomena are still more apparent in connection with reduction of area. At first there is a slight decrease of reduction of area, reaching a minimum at about 300 deg. cent. (572 deg. fahr.), or a temperature corresponding to the maximum on the curve of breaking loads. Then around 450 deg. cent. (892 deg. fahr.) there is a rapid decrease all the more marked the less ferrite the metal contains. After a short level stretch the reduction of area diminishes slightly and then begins to increase until a temperature of about 775 deg. cent. (1427 deg. fahr.) is reached. From this point on various steels show a different behavior depending on their carbon content. Mild steels show a rapid decrease of reduction of area up to 875 deg. cent. (1607 deg. fahr.). This is followed by a wavy curve with a maximum of 100 per cent at about 1050 deg. cent. (1922 deg. fahr.) which occurs simultaneously with the zero of breaking loads (appearance of liquidus).

The minimum in the region of 900 deg. cent. (1652 deg. fahr.) is the less pronounced the greater the carbon content. In the case of eutectoid steels the curve of reduction of area begins to rise at about 600 deg. cent. (1112 deg. fahr.) and attains 100 per cent at 760 deg. cent. (1400 deg. fahr.)

The behavior of 1.25 carbon steel proved to be different from that of the other steels. From this point of view, Fig. 1 is of considerable interest as showing the relation between temperature carbon content and reduction of area in ingot metal not submitted to any previous heat treatment.

The author divides all carbon steels into the following classes below the $A_1$, and $A_2$ as a limit:

Extra mild steel; The ferrite breaks by cleavage before rupture.

Hypo-eutectoid steels: The ferrite alone undergoes noticeable deformation, the rupture taking place when the little islands of pearlite come together.

Eutectoid steels: Rupture practically without deformation.

Hypereutectoid steels: Brittleness due to the presence of cementite.

Austenitic region: No matter what the content of carbon may be, the $\gamma$ iron is completely plastic.

The region between $A_1$ and $A_2$: Plasticity increases with the content of $\gamma$ iron.

Region between $A_2$ and $A_3$: Rupture takes place practically without deformation because of the low content of $\gamma$ iron and the brittleness of iron in the $\beta$ region.

Appearance of liquid material: Sudden and simultaneous falling off in the value of the rupturing load and plasticity. (*Revue de Metallurgie*, vol. 18, no. 6, June 1921, pp. 331–365, numerous illustrations, *etA*)

## FOUNDRY

### Description of Foundry Plant at Warren, Ohio

Continuous Foundry for Pipe Fittings. Henry M. Lane, Mem. Am.Soc.M.E. Description of a foundry plant built at Warren, Ohio, and designed with the view to minimum handling of sand, castings, cores, hot metal and flasks. Only some of the outstanding features will be noted here.

For core making a mixture has been adopted composed of a sharp or lake sand like Michigan City sand, a certain amount of molding sand, and a binder made from waste-liquor refuse from the sulphite paper process. No oil is used. After the mixture is made, it is dropped directly from the bottom of the mixer through a chute into the elevator and passes up to the sand-storage bins over the core room. The secret of the success of this mixture is believed to be largely due to the fact that in a continuous foundry a water-soluble binder may be used as the cores do not remain in the mold long enough to draw dampness.

The production is arranged along the following lines: The molders set out a group of molds at one side of the floor and the pouring gang then comes along and pours this while a group of molds is being put up on the opposite side of the floor. The first group is poured and shaken out and the flasks stacked back before the second group is completed. It is said that they have been able to utilize the floor from four to seven times, depending on the type of work.

In the design of the plant an earnest effort was made to reduce the handling distance to a minimum. It has already been shown how the arrangement of molds minimizes the distance that a molder must carry his molds to set them out. Another economy in distance of handling has been obtained by placing the tumbling bars adjacent to the ends of the casting chutes. The series of casting chutes and the Sly tumbling barrels on the first floor are interspersed. Over the molding floor are a series of underslung cranes with Brillion pouring devices, so that the pouring gang can pour off without the use of hand ladles. The metal is distributed down the gangway in the center by means of monorail. There are other monorails; e.g., one carries the sand from the sand chutes to a bin at the end of the plant, where it is fed to a mixing machine. (*The Iron Age*, vol. 108, no. 9, Sept. 1, 1921, pp. 519–524, 10 figs., *d*)

## HYDRAULICS

### Large High-Head Turbine Unit—Water Leakage and New Labyrinth Seal

Big Creek Development of the Southern California Edison Company. F. H. Rogers. Description of a 30,000-hp. unit designed to operate under a 680-ft. head at a speed of 428 r.p.m., and consisting of a vertical-shaft single-runner Francis type turbine directly connected to a 22,500-kw. 14-pole 50-cycle 11,000-volt generator. The water is led to the turbine through a penstock 2800 ft. long with a diameter of 7 ft. at top and 6 ft. at bottom.

Particular effort was taken to reduce leakage at the runner seals, which is an important factor in the design of high-head units. In this case it is claimed that it is considerably reduced by the use of the Moody labyrinth seal device shown in Fig. 2. In this the leakage water must pass through a series of six seals, at each of which the velocity head is destroyed owing to changes in section and direction of flow. It is claimed that the effective head causing the leakage is only one-sixth of the head for a single seal and that the use of this device will reduce the leakage to only about 0.9 per cent of the full-load quantity, which is about one-third of that which would occur with the single seal.

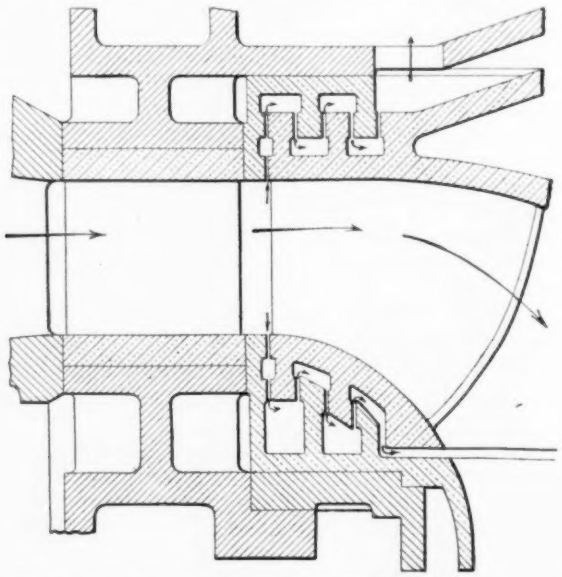


Fig. 2 Section Through Runner of 30,000-Hp. Hydraulic Turbine Showing Labyrinth Seals

As the operation of the unit is continued this leakage loss increases, since the wear at the seals is directly proportional to the velocity of flow through the seals, and as this velocity is about three times as great for the single seal as compared to the labyrinth seal, the wear at the former would be about three times as rapid as for the latter type. It is claimed that after continuous operation for a period of a year the leakage through the labyrinth seal would be only 22 per cent (as compared with 33 per cent for a new turbine) of the leakage occurring with the single seal.

In the usual design of the guide vane there is constant leakage between the top and bottom of the vane and the distributor plates and as this water is not properly guided by the vane it strikes the runner vanes at an incorrect angle causing considerable trouble. The guide vanes in this plant are of the type known as the Overn disk vane (Fig. 3) in which two heavy disks are cast at the junction between the vane and the upper and lower seams. When installed in the turbine the faces of these disks are flushed with the distributor plates so that they prevent any flow above or below the guide vane proper, except for that small portion of the vane which extends beyond the disk. As a result all the water is guided to the runner faces at the proper angle, and when the vanes are in the closed position there is very little leakage.

The original article describes also the draft-tube design, the casting design and the design of the valve.

One of the interesting features of the governor control is the method of change from governor to hand control. In former designs this change usually entailed the closing of three or four large governor valves and the opening of three or four smaller hand-control valves under high pressure. This not only takes considerable time but might lead to serious trouble in case the operator through excitement closes the valves in wrong sequence. In the present installation the governor is furnished with an automatic device known as the Taylor control system, consisting of plunger valves in the governor-base stand operated by oil pressure from the governor system. A single movement of a lever automatically operates all the valves at the same time, closing the governor valves and opening the hand-control valves. (*Power*, vol. 54, no. 7, Aug. 16, 1921, pp. 244–248, 9 figs. *dA*)

Flow of Water Through Galvanized Spiral Riveted Steel Pipe, F. W. Greve. Data of experiments performed in the hydraulic laboratory of Purdue University. The diameters of pipes tested were 4, 6, 8 and 10 in., respectively. The average spacing of the rivets was $^1/_8$ in. for the smaller and $1^1/_8$ in. for the larger pipe. The rivet heads on the inside of the pipes projected $^1/_{10}$ in. from the pipe wall and were flattened to reduce the resistance to flow.

The relation of friction head per 100 ft. of pipe to velocity of flow both with and against laps, is shown in the original article by a graph. The graphs are straight lines indicating that the head loss varies directly as some power of the velocity. They are nearly parallel lines, which demonstrate that the slope varies but little with the size of pipe. From the figure it also appears that the loss decreases with increase of diameter for any given velocity; that the loss is greater for flow against than with laps and that the difference of loss with and against decreases with increase of diameter. It would appear, therefore, that the flow in large sizes approaches the conditions of smooth pipes.

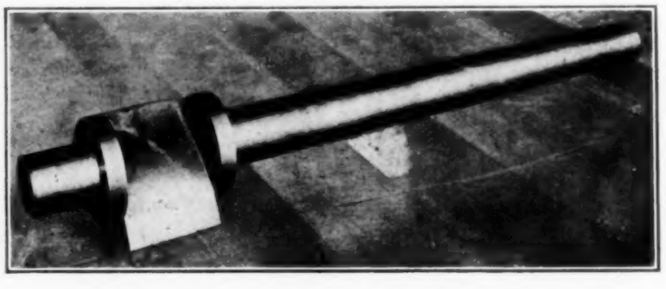


Fig. 3 Guide Vane of the Overn Disk Type

The friction loss may be expressed as $h_L = mv^n$, where $h_L$ is the loss due to friction expressed in feet of water, $v$ the true mean velocity in feet per second, $m$ the value of $h_L$ when $v$ is 1 ft. per sec., and $n$ is the slope that the graph expressing the relation of $h_L$ to $v$ makes with the horizontal.

The original article gives a table showing certain of the variations of $m$ and $n$, these relations being of such a character that they are readily established. On the whole it would appear that the friction loss in galvanized spiral riveted steel pipes when the flow is with the laps is little different from that in smooth cast-iron pipes. (*Engineering News-Record*, vol. 87, no. 4, July 28, 1921, pp. 159–160, 3 figs., *e*)

## MACHINE TOOLS

### Hydraulic Speed Control for Machine Tools

The Oilgear—A Variable Speed- and Feed-Control System for Machine Tools. Description of a speed-control system employing what appear to be some novel devices and permitting a large number of variations of speed and feed without stopping the machine.

The pump unit of the oilgear system comprizes a revolving driver carrying five or seven crossheads and plungers with a corresponding cylinder barrel revolving with the driver and carrying the cylinders in which the plungers reciprocate. By shifting the center of the cylinder barrel the stroke may be varied to suit the conditions to be met. This stroke variation may be met either directly by the

operator or controlled by an outside influence, such as pressure, temperature, centrifugal force, etc.

The motor unit may either be a simple plunger or a revolving multiple plunger unit similar to the pump, except that in the motor the plungers generally have a constant stroke, so that stroke changing mechanism is absent. Because of this the speed of the motor is dependent upon the rate at which the working fluid is delivered by the pump and it varies as the stroke of the pump is increased or diminished.

In addition to this, there is a third unit called the gear pump and acting as a make-up pump for the system. It draws working fluid, which is usually oil from the surplus supply, and keeps several pounds pressure constantly on the intake line of the main pump. It may be also used as a means of rapidly transversing the tool carriage at a speed many times that required for feeding.

The principal unit in the feed-control system is the feed controller, shown in Fig. 4. The controller is essentially a casing including a small variable-delivery pump having a capacity suitable for the small volumes called for in feeding tool carriages, a much larger constant-delivery pump (gear pump) for rapid traverse, a stroke-changing mechanism whereby the operator can accurately set the variable pump-stroke-changing handle, and operating to selectively connect one or the other of the two pumps to the feeding motor according to whether feeding movements or rapid traverse movements are required at the moment.

The plungers are fitted in radial reamed cylinders in the circular cylinder barrel *A*, closely fitted for rotation on a hardened and ground ported pintle *B* and fitted into a swinging arm *C* by means of which the revolving cylinder barrel may be shifted from one side to the other of the revolving driver *D* carrying and operating the plungers. Both driver and cylinder barrel continuously revolve around centers which coincide when the swinging arm is placed in central position and whose distance from one another may be increased in either direction by swinging the arm either to right or left. As the cylinder-barrel axis is moved to right or left the length of stroke of the plunger is correspondingly increased, and results in a flow of oil through the pump in direct ratio to the length of the stroke. This mechanism also gives a reversal of the flow, oil passing through the pump in one direction when the swinging arm *C* is moved to the right, and in the opposite direction when it is moved to the left.

Cam *G* is made with extreme accuracy, giving a speed variation for the tool carriage capable of the finest degree of adjustment. Moreover, after the cam has been swung about through a certain angle it again returns the cylinder barrel to neutral position, thus cutting off the flow from the high-pressure pump and preparing the way for further swing of the control valve which connects the flow from the gear pump to the feed motor, to effect the rapid traverse.

The feed cylinder or motor on a machine tool must have hydraulic fluid on both sides, and the entire system including pipe connections must always be full of fluid under a moderate pressure to exclude air and insure an absolutely steady movement of the tool carriage. The maintenance of this make-up pressure, return of leakage, etc., is an additional function of the gear pump.

Two types of feeding motors are employed—the direct-acting pushing cylinder and the rotary motor. (*American Machinist*, vol. 55, no. 7, Aug. 18, 1921, pp. 271–274, 11 figs., *d*)

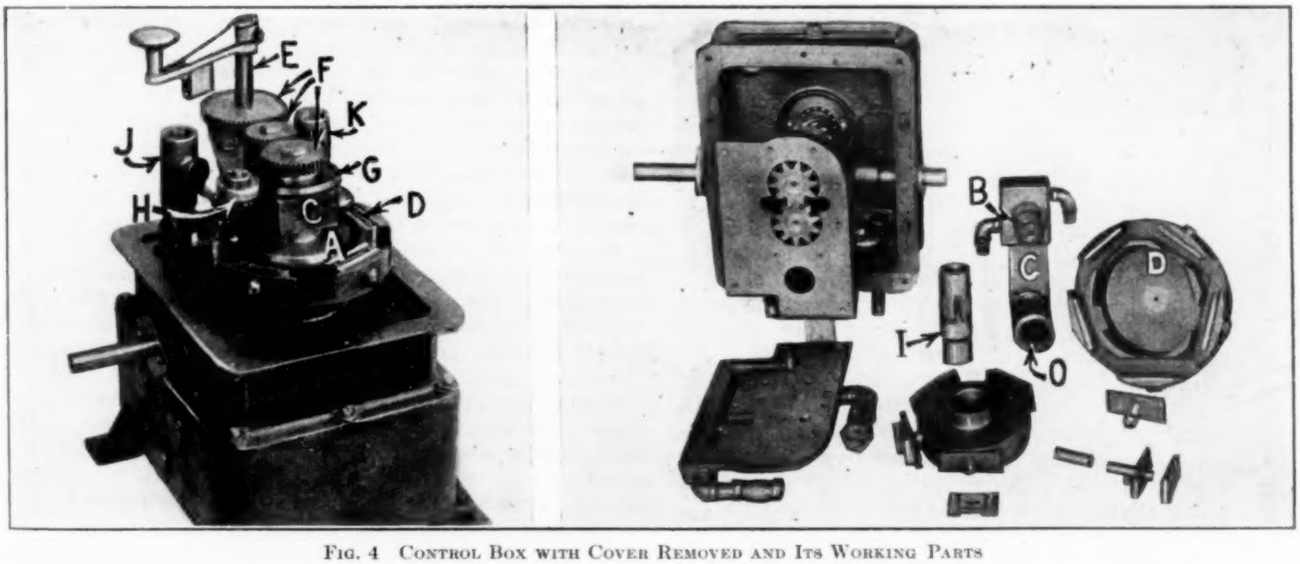



Fig. 4 Control Box with Cover Removed and Its Working Parts

Combination Lathe, Milling and Drilling Machine. Description of a combination machine of American manufacture designed primarily for use in garages, on shipboard and in other places where a rather complete equipment is required and floor space is at a premium (Fig. 5).

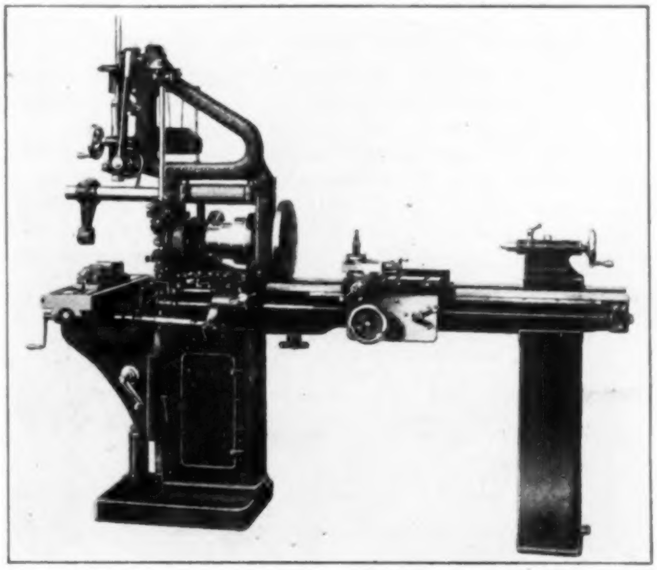


Fig. 5 Combination Lathe, Milling and Drilling Machine

The single hollow spindle serves both the lathe and the milling machine. By removing a section of the shears near the headstock in the lathe it becomes a gap lathe capable of handling faceplate work $18^1/_2$ in. in diameter by $6^1/_2$ in. long, although the lathe itself swings 13 in. over the shears. The removable block is held in place by a tapered dowel bolt.

The drill press can be used only by removing the over arm of the milling machine. A round table is furnished to be attached to the table of the milling machine.

The spindle of the millling machine can be locked rigidly in any position of its vertical travel and it then becomes a vertical milling

machine having all the movement of a standard machine. Hand-wheel and worm, as well as lever feed is provided for the vertical movement.

While the lathe and drilling machine, or the lathe and drill press, may be used simultaneously, the tool is a one-man machine. Usually it can be set up on a floor space of 40 sq. ft. including the room necessary for the operator to get around it. (*American Machinist*, vol. 55, no. 5, Aug. 4, 1921, p. 202, 2 figs., *d*)

## MECHANICS (See Shipbuilding)

## POWER-PLANT ENGINEERING

### Australian Tests on Condenser-Tube Corrosion

Corrosion in Condensers, Ernest Bate. Data of experience and investigation at the Ultimo and White Bay power houses of the New South Wales Railways at Sydney.

The present experience is that pitting causes failure of about 2 to 3 per cent per year of the Admiralty metal tubes in service in the condensers at White Bay, while at Ultimo very little pitting is now experienced but a certain loss of tubes takes place from end erosion and dezincification. Both power houses draw circulating water from Sydney Harbor, though from different bays, and in both cases the water is liable to the usual contamination from ships, surface drainage, stormwater discharges and factories.

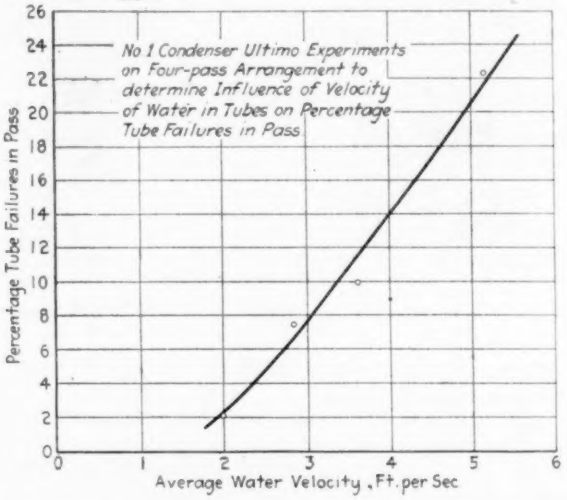



Fig. 6 Influence of Velocity of Water Flow on Erosion of Condenser Tubes

Various kinds of tubes have been used, such as hard-drawn Admiralty mixture brass tubes, practically pure copper tubes, and tubes of patent metal containing about 70 per cent copper and about 29 per cent zinc with small amounts of lead and iron. Formerly tubes tinned inside and out were used, but none have been purchased since 1912 and very few are now in service.

With tubes of similar composition it appears that very different results in the resistance of the metal to corrosion are obtained according to the treatment to which the metal has been subjected.

H. Moore and S. Beckinsale in a paper read before the Sydney Division, Institution of Engineers, Australia, March 10, 1921, stated that almost complete relief of internal stress without softening of Admiralty brass tubes can be obtained by annealing for five hours at 250 deg. cent. (482 deg. fahr.), though the present author shows that annealing of an unsuitable mixture will not enable the metal to give good results in the way of resistance to pitting.

Into one of the units of the White Bay plant, out of a total of 3830 tubes there were placed 342 hard-drawn copper tubes of the composition—copper 99.82 per cent, lead 0.03 per cent, iron 0.04 per cent and arsenic 0.05 per cent. These copper tubes failed by pitting at 80 times the rate of the brass tubes. Within a year about 70 per cent of the copper tubes had become faulty and were removed.

As regards dezincification, trouble was mainly observed with the ferrules. Of tube metal the most liable to dezincification has been found to be a tube of the patented metal above referred to. Bengough and Jones state that layer dezincification is often associated with acid conditions in fresh water. A phenomenon occurred in No. 1 condenser, Ultimo, while under test, which seems in many respects to be a parallel to this redeposit action, and may help to discover the conditions causing it. This condenser was by accident allowed to remain full of circulating water, and very foul, for about three weeks. When opened at the end of that time a rich deposit, consisting of many pounds of crystal copper in tiny fernlike formation, was found over the tube ends, ferrules, tube plates, and end boxes. No other condensers had ever been found in this condition. It was surmised that the condition of standing foul had caused this effect to be produced, and accordingly the copper was cleaned away by flushing, and the conditions repeated. Ultimately it was found that the redeposit could be obtained by allowing the condenser to stand from two to three weeks, but could not be obtained as a rule for one week. During the standing period both injection and discharge valves on the circulating water main were closed.

A sample of water from the injection pipe close to the waterbox was taken on the first occasion of this redeposit. The water was somewhat dark and rusty in appearance. After filtering, the solution was found to contain—zinc, 3.06 grains per gallon; copper 1.40 grains per gallon; iron, 1.19 grains per gallon; free ammonia (inorganic), 0.192 part per 100,000; albuminoid ammonia (organic) 0.640 part per 100,000.

This water sample was, of course, that furthest from the tubes. The filtered water, on standing in a Winchester quart bottle, steadily threw down a brown deposit, the water near the surface appeared brown, and gradually varied to a faint green tint near the bottom. The deposit on analysis proved to be—copper oxide, 10.6 per cent; zinc oxide, 1.44 per cent; oxide of iron and alumina, 49.32 per cent; insoluble matter, 15.46 per cent; organic matter, 17.93 per cent; combined water, 4.38 per cent; undetermined, etc., 0.78 per cent.

This was not a large condenser. The tubes are mostly tinned and of Admiralty mixture. It is clear that during the standing period copper had passed into solution very freely, that this copper-rich solution had by convection or otherwise appeared at the water box, and had there deposited most of the copper held in solution. The ferrules showed no sign of attack. It seems clear that the condition of the solvent in the tubes was such that the solution pressure of zinc was, for some period at any rate, less than that of copper. Moving to the water boxes this solution of copper underwent a change such that zinc and iron slowly displaced the copper.

An attempt was also made to investigate the influence of velocity of flow on pitting, and it would appear from Fig. 6 that the percentage of failures was about proportional to the square of the velocity of flow. However, the tubes tested were mostly old and the result obtained is regarded purely as indicating the effect of flow in accelerating corrosive effects. The thermal factor appears to be also of importance in this connecton.

An investigation of the influence of intake water particularly as affected by its composition has been started and some data are presented in the original article. (*The Commonwealth Engineer* [Melbourne, Australia], vol. 8, no. 11, June 1, 1921, pp. 339–343, 8 figs., *e*)

Ford's Power Plant May Be Abolished. The enormous power plant at the Ford Highland Park factory, long the pride of Henry Ford, is soon to be transformed from a gas-steam plant to an all-steam plant, or is to be abolished entirely. Engineers, headed by Wm. B. Mayo, are now determining the most economic method of handling the power situation.

The gas-steam plant has been in operation for over ten years and a point has been reached where gas-steam power is no longer as economical as steam power alone.

Two plans are under consideration. The first involves the junking of the producing gas plant and installation of additional steam boilers. This would cost approximately $2,000,000. The second plan is to eliminate the Highland Park power plant entirely and bring high-tension power from the River Rouge, which would require an addition to the latter plant. This cost approximates $3,000,000.

There will be no interference with operations at the Highland Park plant while the power changes are under way. The Detroit Edison Co., which has a power house nearby, would furnish 90 per cent of the present peak power, which runs about 75,000 hp. (*Automotive Industries*, vol. 45, no. 9, Sept. 1, 1921, p. 438)

## RAILROAD ENGINEERING

### Consolidation Locomotives on the D. & H. and W. M.

High-Capacity Consolidation-Type Locomotives. During the past 10 or 12 years locomotives of the Mikado type have to a large extent displaced Consolidations in heavy main-line freight service. The consolidation is still used to a considerable extent, especially for heavy drag service where slow speeds suffice and fuel conditions do not require the boiler and firebox proportions that can be obtained in the Mikado type. The purchase of 40 heavy Consolidation-type locomotives by the Western Maryland Railway and the use of locomotives of the same type purchased a few years ago by the Delaware and Hudson Company show the vitality of this type. In particular, it is claimed that with driving wheels of the size that are suitable for slow-speed heavy-duty service, it is possible in a Consolidation design to use a firebox throat of sufficient depth to install a brick arch without raising the boiler to an excessive height.

Among the particular features of the new Western Maryland locomotives may be mentioned the following:

The frames are 6 in. wide, spaced 41 in. between centers, and each frame is cast in one piece with a single front rail to which the cylinders are bolted. A substantial steel casting, placed just back of the cylinders, extends the full length of the leading driving pedestals and serves as a fulcrum for the driving brakeshaft. The guide-yoke cross-tie is also of cast steel, and it is extended back sufficiently far to brace the second driving pedestals. This cross-tie also serves as a support for the driving-brake cylinders, one of which, because of the lack of room, is placed in a horizontal, and the other in a vertical, position.

The driving boxes are of cast steel and are fitted with bronze hub faces and brass-lined pedestal faces. Cast-iron shoes and wedges are used, the latter being of the self-adjusting type. The driving axles and engine-truck axle are of heat-treated steel, and flanged tires are used on all the wheels. Flange oilers are applied to the front and back drivers. The ashpan has two hoppers with swing bottoms, both of which are controlled by one handle. Flushing pipes are applied for washing ashes from the slopes of the pan. The injectors and steam turret are placed outside the cab and have extension handles identified by small aluminum plates with raised letters. The equipment includes a breather pipe for providing fresh air while passing through tunnels. This arrangement consists of a $^1/_2$-in. pipe placed across the boiler back head and having five $^1/_4$-in. globe valves equally spaced, each fitted with three feet of $^1/_2$-in. hose. The air supply is drawn from the brake system.

In the Delaware & Hudson Consolidations, the design of the ashpan proved to be quite a difficult problem which was met by the construction of an ashpan having six distinct hoppers and doors. Ample airway for combustion requirements is provided through a 6-in. opening between the pan and the mud ring. The tender construction is unusual for a locomotive of this capacity, in that it is supported upon an underframe of built-up structural shapes with heavy center-sill section, such as is employed in car construction.

In the Delaware & Hudson units the per cent of boiler horsepower to cylinder horsepower is higher than in the Western Maryland (92 as compared with 85 per cent), and this difference is ascribed to the relatively larger percentage of firebox heating surface to total heating surface in the Delaware & Hudson Consolidation, since each square foot of firebox surface is equivalent in evaporating capacity to more than 5 sq. ft. of tubular heating surface. This only serves to emphasize an inherent limitation in the Consolidation-type locomotive. On account of the limited flue length and firebox dimensions, it is impossible to secure horsepower equal to cylinder powerhorse in high-capacity locomotives of this type without the use of thermic siphons or other means of augmenting firebox or tubular heating surface. (*Railway Review*, vol. 69, no. 7, August 13, 1921, pp. 197–205, 15 figs., *d*)

## SHIPBUILDING

### Gyroscopically Stabilized S.Y. "Lyndonia"

Gyroscopic Stabilization for Ships. Compounded abstract of several articles devoted to the subject of reducing the rolling of a ship by means of gyroscopic stabilization.

E. A. Sperry, Mem. Am.Soc.M.E., points out that in gyroscopic stabilization the roll of a ship is not actually reduced but suppressed by dealing only with its beginnings. All rolling of ships is a gradual accumulation of individual wave increments, and if these single increments are quenched the rolling is done away with.

In the actual construction a little gyro "feeler" (control gyro) detects the incipient roll at its beginning and also shows its direction. From it, through a relay and motor, the large gyro is artificially precessed and delivers stresses of opposite sign to the ship. As a result the ship never starts to roll. The process is said to involve not only a relatively small apparatus but entails merely comparatively small stresses in the hull, said to be from one-sixth to one-tenth those present in a rolling ship.

Alexander E. Schein, Mem. Am.Soc.M.E., in an article entitled, The Gyroscopic Stabilizer on the S.Y. *Lyndonia*, covers

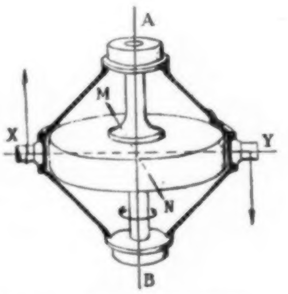



Fig. 7 Simple Gyro Illustrating Precession

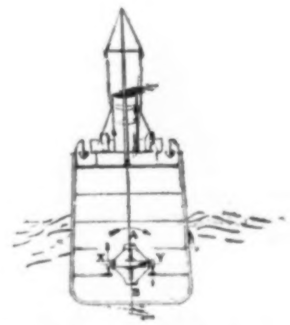



Fig. 8 Elementary Form of Ship Stabilizer

practically the same field as the previous article in a much more detailed way.

Fig. 7 shows a simple gyroscope which will illustrate the principle of the stabilizer. It consists of a rapidly spinning wheel with axis vertical, mounted in pivot bearings within a vertical ring. There are two trunnions on this ring forming a horizontal axis $XY$. If the trunnions $X$ and $Y$ are mounted in bearings the whole mass is then free to turn about the horizontal axis $XY$. Imagine the wheel to be spinning in the direction of the arrow on its rim, and that we apply forces at $X$ and $Y$. The effect would be to turn the whole mass about a third axis $MN$. But just here is where the gyroscopic effect comes in. If we assume that the wheel is of sufficient size we can represent forces $X$ and $Y$ by two people, one of whom attempts to lift at $X$ and the other depress at $Y$. There will be two very evident effects due to gyroscopic action. The first to be noticed is the great resistance the gyroscope offers to any effort to turn it about the axis $MN$ by means of forces $X$ and $Y$. The second effect is that point $A$ will be seen to move away from us, and point $B$ toward us about the axis $XY$. These two actions together are known as precession. One is never present without the other. In order to have resisting forces we must have angular movement, and conversely with an angular movement there must be forces. It will be noticed that there are three axes involved in precession. First there is the axis of spin—the axis about which the wheel rotates. Secondly, there is the axis of spin at right angles to the first, about which the forces act. And third, there is the axis of precession about which the gyro turns when forces are applied about the second axis. This third axis is perpendicular to each of the other two. The first axis is represented in Fig. 7 by $AB$, the second by $MN$, and the third by $XY$. Precession may therefore be simply defined as an angular movement accompanied by a resisting moment, both of which are at right angles to the axis of spin and to each other. This principle

is made use of in the gyro ship stabilizer. Just how it is done is evident from Fig. 8, which shows the same gyroscope mounted in a ship. The axis $MN$ is now the axis about which the ship rolls. As soon as there is any angular movement due to rolling, the gyroscope resists it by forces at $X$ and $Y$, and at the same time precesses about axis $XY$. If the direction of roll reverses the forces will also reverse and so will the precession about $XY$. The gyro automatically exerts forces in the proper direction and it is continually oscillating back and forth on the $XY$ axis. In a general discussion about the ship stabilizer the turning movement of the gyro is known as precession, although as defined above precession strictly takes into consideration the forces acting. In this article "precession" will be taken to mean the angular motion of the gyro, and when the forces are referred to, the term will be "gyroscopic force" or "gyroscopic moment." This separation of the two actions simplifies the discussion and is the common practice when speaking of stabilizers.

In Fig. 8 is shown the simplest form of ship stabilizer. In actual design the rotating wheel, or rotor, is mounted in bearings and enclosed in a casing. On this casing there are two gudgeons corresponding to points $X$ and $Y$ through which the forces are transmitted to the ship. It remains only to limit these forces so that they will not be excessive and cause undue stresses in the hull. The well-known formula for gyroscopic moment is:

$$M = \frac{k^2WR}{307}\,n$$

where $k^2W$ is the moment of inertia of the rotor, $R$ the revolutions per minute of the rotor, and $n$ the angular velocity of precession in radians per second. The moment will be in foot-pounds. If we omit the complexity of mathematical expressions the above moment is approximately equal to the tilting moment produced by the maximum effective wave slope, and if such a moment were applied to a non-rolling ship during the period of oscillation it would cause the ship to roll an amount about equal to the maximum roll increment. The stabilizing moment is therefore only slightly greater than the natural effect of the waves causing the ship to roll, and in case of the *Lyndonia* is only about 375,000 ft-lb.

From the formula it is seen that we can control the magnitude of the gyroscopic moment by varying either $R$ or $n$. It would be impossible to vary $R$ quickly and easily. But with $R$ constant it is an easy matter to vary $n$ and hence $M$. Stabilizers are therefore designed for some known value of $R$ which will not overstress the wheel, and the gyroscopic forces transmitted to the ship limited by limiting the speed of precession by mechanical brakes or other means. This type of stabilizer is known as the passive gyro stabilizer. It uses the forces of the waves to start gyro precessing, and mechanical brakes suitable pistons and levers to control within close limits the speed of precession. Due to the fact that the mass of the casing and wheel is necessarily large it takes several seconds to get the speed of precession up to normal velocity, and therefore the ship has gained considerable roll before full stabilizing is obtained. The passive-type stabilizer cannot decrease the roll to less than six or seven degrees.

Mechanical details of construction of the *Lyndonia* stabilizer are given in an article by W. T. Manning, while the electrical equipment is described by T. P. Kirkpatrick and H. C. Coleman. (*The Electric Journal*, vol. 18, no. 8, Aug. 1921, pp. 335–349, illustr., *dA*)

## CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

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From information published in some of the British motor papers it would appear that the famous German Mercedes motor works, which during the war have built many of the German aircraft motors, are now working on a supercharged type of engine for automobiles and trucks. The president of that company states, though, that only very slight increases in power can be obtained by applying the principle of superinduction without a complete re-design of the motor.

## IMPORTANCE OF OIL-INJECTION TYPE OF INTERNAL-COMBUSTION ENGINE

(*Continued from page 658*)

form, by Nielsen, who also provided for adjustment of injection-chamber volume by a special cover or cap.

Still another type brought out in the course of development of the divided combustion chamber is the Leissner, Fig. 23. Leissner adds to the Nydahl or Neilsen injection chamber a tube which has holes in the sides and bottom to form the old-fashioned fuel distributor used with air- and solid-injection spray valves. The Leissmer tube comes up close to the injection spray nozzle which delivers the oil inside the tube. Just as the small injection chamber alone prevents development of explosive shocks by limited contact of air and fuel, so does insertion of this tube add something to further limit the contact control. Leissner specifies that the holes through the bottom and sides of the tube, and the space above it, shall be so related to each other in area as to produce the following series of actions: Compression carried first to ignition temperature; injection inside the tube in the injection chamber and partial combustion in the tube, producing a rise of pressure in the tube, which in turn projects jets of still unburned oil sidewise into the air around the tube. Combustion of these jets raises the pressure outside of the tube and causes reversal of flow back into the tube and down through it to the cylinder, helped by the movement of the piston; the air left around the tube finally passing through the tube and expelling the fuel charge in front of it into the cylinder, the space around the tube and in the tube being in series. This

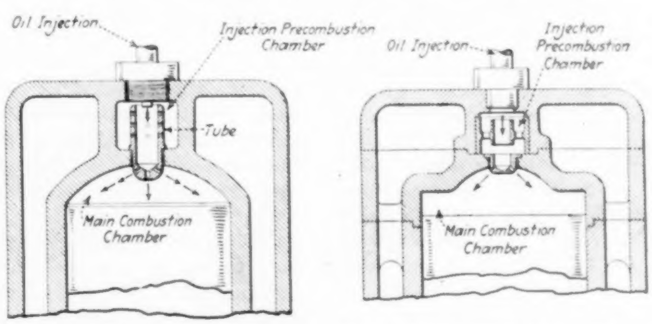



Fig. 23 Leissner Divided Cold Combustion Chamber
Fig. 24 Worthington Divided Cold Combustion Chamber

is a new engine brought out in Sweden, and it is now being introduced into this country.

Finally, in this class of divided-combustion-chamber injection engines there is a new one developed by Worthington—the class in which the injection or precombustion chamber is used to limit the development of explosive shocks and connected to the cylinder by an ejection orifice through which gasified fuel is expelled to the cylinder by a pressure differential due partly to the movement of the piston and partly to the precombustion. This is shown in Fig. 24. It has a tube open at both ends and supported from the side walls with wide spaces at each end. The bottom of the injection chamber has a passage to the cylinder of the usual fuel-distributing sort, forming a fuel-ejection orifice. There are large holes through the tube-supporting web, so that the injection chamber acts as a single chamber, with the tube acting as a sort of fuel baffle or guard. The charge being injected into the tube is limited by the tube as to air contact. The tube constitutes a fuel guard, by means of which the amount of precombustion can be controlled and at the same time the fuel is gasified in the hot limited amount of air. A rise of pressure in the injection chamber, due to partial combustion, is suppplemented by depression of the pressure on the cylinder side due to the piston movement, which starts the flow of parallel streams of air and fuel toward the cylinder. This action creates in effect a bunsen burner in the top of the cylinder. This arrangement gives a construction practically as simple and foolproof as the little Hvid, except for the injection pump, but one that seems to be adapted to a wider range of cylinder sizes and speeds and less limited by fuel quality.

Much experimental research has already been completed and more is planned, to be presented in a later paper.

# ENGINEERING RESEARCH

## A Department Conducted by the Research Committee of the A.S.M.E.

### A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulas or curves where such may be readily given, and to report results of non-extensive researches which, in the opinion of the investigators, do not warrant a paper.

*Aircraft A3-21.* Air Propellers. The work of Prof. W. F. Durand and E. P. Lesley on (*a*) air screws in yaw and (*b*) a general analysis and résumé of the results of detailed investigations of 88 air-propeller models for the determination of the general laws covering the entire series has been completed and submitted to the National Advisory Committee for Aeronautics. Address Prof. W. F. Durand, Leland Stanford Junior University, Stanford University, Cal.

*Apparatus and Instruments A8-21.* Tearing Instruments and Tests for Paper. Technologic Paper 194 of the Bureau of Standards may be obtained from the Superintendent of Documents, Washington, D. C. at 5 cents per copy. The paper reports the study of the effect of different sizes of test samples on tearing strength of paper. It has been found that the larger the sample the greater the value of the tearing strength owing to fabric assistance. One instrument is used for tensile strength and two instruments for tearing strength. It was impossible to calibrate one type of tearing instrument because of friction in certain parts of the mechanism. The other was accurate within 5 per cent. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

*Cement and Other Building Materials A10-21.* Fire Tests on Building Columns. The fire tests on building columns reported previously were made at the Underwriters Laboratory at Chicago, Ill. The report of these tests is found in a publication which may be obtained at $2 per copy in paper covers and $2.50 per copy in cloth covers from the Associated Factory Mutual Fire Insurance Companies at 31 Milk St., Boston, Mass., or at the Underwriters Laboratories, 207 East Ohio St., Chicago, Ill. The report covers 389 pages and contains the following sections:

1 Introduction
2 Description of Columns
3 Schedule of Tests
4 Placing of Covers and Concrete Columns
5 Auxiliary Tests of Materials
6 Description of Furnace and Related Equipment
7 Temperature Measurements
8 Deformation Measurements
9 Method of Testing
10 Results of Fire Tests
11 Results of Fire and Water Tests
12 General Summary and Discussion
13 Fire Resistance Periods from the Test Results

The appendices give various data, including photographs of the columns before and after testing, curves of temperature and time and curves of deformation and average temperature.

There were 106 tests of columns, of which 91 were fire tests and 15 fire-and-water tests. The fire tests included tests of representative types of unprotected structural steel, cast iron, concrete-filled, pipe and timber columns; columns with metal partially protected with concrete, columns with 2-in. or 4-in. thickness of concrete, tile, brick, gypsum block or plaster as a protection, and reinforced-concrete columns with 2 in. of integral concrete protection. Materials used for protection and the constituent materials were tested. The columns were designed for a working load of approximately 100,000 lb. and the load was maintained constant during the test. Measurements were taken of temperature of furnace and the deformation due to the load when heated. In the fire-and-water test the columns were loaded and exposed to the fire a predetermined time. Address Underwriters Laboratories, 207 East Ohio St., Chicago, Ill.

*Cement and Other Building Materials A11-21.* Fire Test of Brick Panels. A fire test of 8-in. solid restrained panel of eastern brick and two tests on 8-in. hollow unrestrained panels, one of eastern and one of western brick, were made at the Bureau of Standards during July. Except for the fact that the eastern brick did not fuse on the exposed side during test, no difference was noted in the two kinds of bricks. No collapse occurred. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

*Cellulose and Paper A2-21.* Tearing Instruments and Tests. See *Apparatus and Instruments A8-21.*

*Fuels, Gas, Tar and Coke A13-21.* Iowa Coals. Technical Paper 269 on Analysis of Iowa Coals by George S. Rietz, A. C. Fieldner and F. D. Osgood, includes the geology of the coal beds, the coal resources, the character of the coal, development and transportation, uses, fusibility of ash, coking properties, markets, future developments and chemical analysis. The paper ends with list of publications on the composition of coal. Bureau of Mines, Washington, D. C. Address H. Foster Bain, Director.

*Fuels, Gas, Tar and Coke A14-21.* Water-Gas Apparatus. Water-Gas Apparatus and the Use of Central District Coal as Generator Fuel is the subject of Technical Paper 246 of the Bureau of Mines. The paper was prepared under a coöperative agreement with the Illinois State Geological Survey and the Engineering Experiment Station of the University of Illinois. The paper describes modern apparatus, distribution of heat, blasting reactions, requisites for efficiency, production of coke and coal as generator fuel, design of generator set, depth of fuel, and closes with a list of publications on producer gas. Bureau of Mines, Washington, D. C. Address H. Foster Bain, Director.

*Internal-Combustion Engines A4-21.* Fuel Economy. The Bureau of Standards has investigated the effect of introducing exhaust gases with the explosive mixtures for a gas engine for the purpose of obtaining a high compression ratio for low powers. An engine was operated with the leanest air-fuel ratio which would ignite regularly and it was again operated with a sufficient amount of exhaust gas with a charge to reduce the engine power to the same value as had been obtained in the first test by throttling. Although the pressures in the latter test were considerably higher than in the first test, the limiting air-fuel ratio for firing was not as great and a lower thermal efficiency resulted. It seems fair to conclude that the dilution of the charge by the spent gas makes it impossible at low throttles to employ the air-fuel ratios which give maximum efficiency. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

*Machine Design A3-21.* Strength of Screw Fastenings in Plywood. It is important that size of screw spacing and margin of screw fastenings in plywood should be adapted to the species and thickness of plywood used. The Forest Products Laboratory has found that commonly used plywoods are divided into the following groups:

| Group I, Low Density | | Group II, Medium Density | | Group III, High Density |
|---|---|---|---|---|
| Basswood | Hemlock | Ash, black | Hackberry | Ash, white |
| Cedar, Spanish | Pine, sugar | Ash, pumpkin | Magnolia | Beech |
| Cottonwood | Pine, white | Elm, white | Mahogany | Birch |
| Cypress, bald | Poplar, yellow | Gum, black | Maple, soft | Cherry, black |
| Douglas fir | Redwood | Gum, cotton | Sycamore | Elm, cork |
| Fir, true | Spruce, Sitka | Gum, red | Walnut, black | Maple, hard |

The data regarding screws are found in the following table, the gage being the smallest that can be used with the thickness specified and not cause failure through breaking of the screws when full strength of plywood is developed and the length being the shortest that will prevent the screw pulling out before the full strength of the wood is reached. The margin is the minimum margin for full development of strength.

| Species of plywood | Thickness of plywood, in. | Gage (Number) of screw | Screw length, in. Species receiving point: White ash | Spruce | Margin, in. | Spacing, in. |
|---|---|---|---|---|---|---|
| Group I | 3/30 | 4 | 1/2 | 5/8 | 1/2 | 3/8 |
| | 3/24 | 5 | 1/2 | 5/8 | 5/8 | 1/2 |
| | 3/20 | 6 | 5/8 | 3/4 | 5/8 | 1/2 |
| | 3/16 | 7 | 5/8 | 3/4 | 5/8 | 5/8 |
| | 3/10 | 9 | 3/4 | 1 | 3/4 | 3/4 |
| | 3/8 | 11 | 1 | 1 1/4 | 3/4 | 3/4 |
| Group II | 3/30 | 5 | 1/2 | 5/8 | 1/2 | 1/2 |
| | 3/24 | 6 | 5/8 | 3/4 | 5/8 | 1/2 |
| | 3/20 | 7 | 3/4 | 7/8 | 5/8 | 5/8 |
| | 3/16 | 8 | 7/8 | 1 | 5/8 | 3/4 |
| | 3/10 | 10 | 1 | 1 1/4 | 3/4 | 3/4 |
| | 3/8 | 12 | 1 1/4 | 1 1/2 | 3/4 | 7/8 |
| Group III | 3/30 | 6 | 5/8 | 3/4 | 1/2 | 1/2 |
| | 3/24 | 7 | 3/4 | 1 | 5/8 | 5/8 |
| | 3/20 | 8 | 1 | 1 1/4 | 5/8 | 3/4 |
| | 3/16 | 9 | 1 1/4 | 1 1/2 | 5/8 | 3/4 |
| | 3/10 | 11 | 1 1/2 | 1 3/4 | 3/4 | 7/8 |
| | 3/8 | 13 | 1 3/4 | 2 | 3/4 | 1 |

Equally good results were obtained with flat-headed screws without washers and round-headed screws with washers. Round-head screws without washers proved an inferior means of fastening. The spacing given in the table is for screws in a single row, but staggering is recommended when possible. The tests were made without reference to the member to which the plywood was attached. Until further information designers must take care that the frame is not split or weakened through the use of the size of screw and spacing necessary to make the fastening as strong as the plywood. U. S. Forest Products Laboratory, Madison, Wis. Address Director.

*Metallurgy and Metallography A14-21.* Graphitization in Cast Iron. The microscopic study of various specimens of cast iron after prolonged annealing indicates that considerable change in the combined carbon occurs below the thermal critical range (about 700 deg. cent.). This graphitization does not occur below 500 deg. cent. after a very prolonged heating period. The microscopic study reveals many interesting and valuable facts not shown by chemical analysis alone. In

low-temperature graphitization only the pearlite is not affected. The free carbide does not appear to change until the thermal critical point has been passed and the solution of this constituent has begun. The form in which the graphite exists after annealing depends on initial structure. If flakes of graphite exists they act as nuclei for the deposition of the graphite formed during annealing. If no flakes are present the graphite takes the form of small globules. The data from furnace work, chemical analysis and microscopic examination are being put in shape for publication for a supplement to Technologic Paper 129. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

*Metallurgy and Metallography A15-21.* TEMPERING HARDENED STEELS. An investigation on the structural changes occurring in hardened steels upon tempering has progressed far enough to show that there is a decided change brought about by tempering at approximately 240 deg. cent. Up to that temperature no structural change is to be seen. In all cases the changes which occur are relatively inconspicuous and this accounts for the lack of data relating to this subject. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

*Mining, General A6-21.* VENTILATION IN METAL MINES. Technical Paper No. 251 by Daniel Harrington is devoted to a preliminary report on ventilation in metal mines. The bulletin explains the method used in determining the physical data as a basis of the paper and then describes the elements which control metal-mine ventilation. It also describes the conditions effecting the temperature of mine air, relative humidity of mine air and the composition of mine air, giving the effect of dust and velocity, as well as methods for providing efficient ventilation, with its control and cost. A list of publications of the Bureau of Mines dealing with mine gases and mine ventilation is appended. Bureau of Mines, Washington, D. C. Address H. Foster Bain, Director.

*Mining, General A7-21.* ACCIDENTS IN METAL MINES. During the calendar year 1919 the number of operators reported to the Bureau of Mines was 145,262. The average employment of these men was 281 days per year per man. The number of men killed was 468 and the number of men injured was 31,506. The report shows that for every thousand men employed for 300 working days 3.31 were killed and 231.8 injured enough to cause them to lose at least one day's time. This is the lowest record of fatality in the metal-mining industry of the United States and the injury rate is lower than any year since 1914. Bureau of Mines, Washington, D. C. Address H. Foster Bain, Director.

*Mining, General A8-21.* COAL-MINE FATALITIES. Technical Paper No. 228 of the Bureau of Mines states that during 1920, 2260 men were killed in the coal mines of the United States, a decrease of 57 from the record of the year before. This reduction occurred with an increase of 18 per cent in the output of coal. 3.50 lives were lost for every million tons of coal in 1920, while in 1919 there were 4.24 lives lost. In 1920 there were 775,000 men employed in mines while in 1919 the number was 765,000. The total production of coal was 645,663,000 tons, of which more than five-sixths was bituminous coal. There was a decrease of 64 per cent in fatalities due to fires, a decrease of 38 per cent in fatalities due to explosives and a decrease of 14 per cent in deaths resulting from the explosion of gas and coal dust. This bulletin includes a list of permissible explosives, lamps and motors and gives a list of certain approved mine-rescue apparatus. It gives a list of state mine inspectors and other mine officials. Bureau of Mines, Washington, D. C. Address H. Foster Bain, Director.

*Railway Rolling Stock and Accessories A1-21.* STRESSES IN CAR WHEELS. Special runs on car wheels were made in which strain measurements in radial and tangential directions on both faces of the wheel were taken. Results indicate that no tangential stresses are set up in the wheel as a result of heating. On the front side of the wheel tension exists near the hub and compression near the rim, while stresses of equal magnitude but of opposite sign exist on the other side. The stress distribution appears to be a result of the shape of the wheel. Similar tests will be made on wheels from each of the other manufacturers. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

*Steam Power A2-21.* STEAM CONSUMPTION OF TURBINES. Carroll Stansbury and Louis Weil have determined that the steam consumption of a steam turbine may be found by measuring the quality of the steam at entrance to and discharge from a turbine. From the steam tables the heat contents at the two points may be found and from these the water rate is given by

$$w = \frac{2546.5}{F\,(H_1 - H_2)}$$

where $w$ = lb. of steam per hp-hr.

$F$ = factor = $p/(p + pf)$

$H_1$ = heat content at entrance for observed pressure and quality

$H_2$ = heat content at discharge for observed pressure and quality

Steam should be superheated at both points for simple measurement of quality.

$p\!f$ = horsepower developed by turbine

$p\!f$ = horsepower equivalent to heat in radiation residual velocity and mechanical friction

$$= \frac{K}{2546.5}$$

where $K = w_0\,(H_{01} - H_{02})$

$w_0$ = steam consumption per hour at no load.

$H_{01}$ = heat content at entrance, no load

$H_{02}$ = heat content at discharge, no load.

Tests of this method have shown very close agreement with practice. Johns Hopkins University, Baltimore, Md. Address Prof. A. G. Christie.

*Wood Products A6-21.* STRENGTH OF SCREW FASTINGS IN PLYWOOD. See *Machine Design A3-21.*

*Wood Products A7-21.* GLUE STAINS. Casein and vegetable glues containing caustic soda produce stains on certain woods such as oak, maple, cherry, elm, ash, birch and beech. This is due to the action of the alkali on the tannins and other constituents of the wood whereby an inky substance is formed. No means can be found to prevent this chemical action. Precaution will keep the discoloration from the finished surface. If veneers are less than $^1/_{20}$ in. thick, glue will seep through pores, hence thicker glues are used with fillers added when staining is feared. If a panel is dried promptly the caustic soda will have difficulty in coming to the surface. Rapid drying by removing panels from press as soon as possible and placing them on stickers is advisable. These stains can be removed by sponging the stained surface with a solution prepared by dissolving one ounce of oxalic acid crystals in 12 ounces of water. Still better results may some times be obtained by first moistening wood with sodium sulphite solution of similar concentration to the oxalic solution. U. S. Forest Products Laboratory, Madison, Wis. Address Director

*Wood Products A8-21.* SUBSTITUTES FOR ASH. The Forest Products Laboratory has published Technical Note 147 showing how maple, elm, birch, hickory, red gum, oak and Southern yellow pine may replace ash for certain parts of automobile bodies. The note gives the relative values of these different woods in terms of ash as per table below.

U. S. Forest Products Laboratory, Madison, Wis. Address Director.

| SPECIES | Strength as a beam or post | Stiffness | Shock-resisting ability | Hardness |
|---|---|---|---|---|
| Ash, white, forest-grown.. | 100.0 | 100.0 | 100.0 | 100.0 |
| Ash, black | 71.3 | 79.3 | 90.1 | 62.3 |
| Ash, white, second-growth | 122.5 | 117.6 | 119.6 | 118.9 |
| Basswood | 59.1 | 80.6 | 40.5 | 29.6 |
| Beech | 93.5 | 96.9 | 96.0 | 90.0 |
| Birch, yellow | 104.8 | 116.8 | 120.6 | 80.9 |
| Chestnut | 66.0 | 71.9 | 53.4 | 49.2 |
| Cottonwood | 60.6 | 79.0 | 54.3 | 35.3 |
| Cucumber | 85.4 | 112.4 | 76.7 | 54.9 |
| Elm, rock or cork | 98.8 | 92.9 | 140.5 | 101.6 |
| Elm, white | 79.2 | 79.5 | 89.5 | 57.1 |
| Gum, red | 80.7 | 91.5 | 75.5 | 59.0 |
| Gum, tupelo or cotton | 81.4 | 82.5 | 63.5 | 77.3 |
| Hickories, pecan | 103.5 | 103.8 | 119.7 | 139.6 |
| Hickories, true | 126.6 | 120.2 | 173.9 | 150.4 |
| Maple, red | 90.0 | 101.2 | 78.7 | 75.4 |
| Maple, silver | 66.9 | 68.5 | 71.7 | 64.3 |
| Maple, sugar | 104.7 | 105.9 | 90.5 | 103.0 |
| Oaks, all kinds | 92.6 | 101.3 | 94.9 | 104.5 |
| Poplar, yellow | 67.3 | 93.8 | 41.5 | 37.9 |
| CONIFERS | | | | |
| Fir, Douglas, Pac. Coast | 95.7 | 122.1 | 59.9 | 58.3 |
| Pine, loblolly | 93.7 | 105.6 | 71.0 | 60.0 |
| Pine, longleaf | 112.2 | 122.1 | 77.7 | 74.8 |
| Pine, shortleaf | 94.1 | 100.6 | 69.7 | 64.0 |
| Pine, western white | 75.5 | 99.7 | 53.8 | 37.0 |
| Pine, western yellow | 67.0 | 75.6 | 42.9 | 41.0 |
| Spruce, Sitka | 69.5 | 94.1 | 63.3 | 44.9 |

## B—RESEARCH IN PROGRESS

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for coöperation or conference, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

*Air B5-21.* REHEATING. The effect of internal- and external-combustion air reheaters and the thermodynamic efficiencies secured through the use of reheated air in air motors is being investigated by Dean C. R. Richards and J. N. Vedder. Three types of reheaters were tested and also steam was used as the reheating agent. The reheated air is used in a small Corliss engine, the load being adjusted to give complete expansion. The results so obtained were compared with those when cold air was used. Address Dean C. R. Richards Engineering Experiment Station, University of Illinois, Urbana, Ill.

*Automotive Vehicles and Equipment B6-21.* COST OF OPERATING TRUCKS. The Automobile Section of the Mechanical Engineering Laboratory of the University of Michigan is calibrating several four-ton trucks so that the Highway Department can determine economical data regarding trucks in service. These trucks are being calibrated to determine the losses in the engine, in the transmission system from engine to bearings and differential gears and to determine the power required to roll the truck along the level road on various grades with different loads. In doing this the truck is brought into the laboratory and the engine placed on a testing stand to determine horsepower, fuel economy and mechanical efficiency. The manifold suction is observed for every run. The engine is then replaced in the truck which has been mounted between two dynamometers with axle jackshafts connected to the armature shafts of the dynamometers. The engine is then run at a speed and manifold suction corresponding to one of the runs on the engine stand. The power output of the transmission is then determined and from the previous calibration of the engine alone the efficiency of the transmission system is then determined. The truck is then operated on the road with different loads and on different grades by pulling it

by means of a drawbar dynamometer from another truck. The truck will then be operated on various grades and at various loads and the fuel consumption measured at different stations at about 100-ft. intervals. University of Michigan, Ann Arbor, Mich. Address W. E. Lay.

*Boilers and Accessories B1-21.* Super Boiler Test. The Detroit Edison Company is making a test on one of its large boilers at the Connors Creek plant. This test will cover a period of about ten weeks. The purposes of this test are:

1 To determine the most economical coal with particular reference to the ash content of the coal

2 To determine how many improvements can be made in the present baffle arrangement.

3 To determine the relation between frequency of blowing the flues and economy, and

4 To determine the banking losses of the boiler.

Detroit Edison Company, Detroit, Mich. Address Paul W. Thompson.

*Cement and Other Building Materials B2-21.* Concrete. A number of researches have been planned by Prof. A. N. Talbot on the measurement of mobility of fresh concrete and a general investigation of concrete and one on the effects of graduating the particles of the aggregate as well as varying the amount of water and cement in making the mixture. It is planned to determine the proper quantity in a mixture to obtain a workable concrete, to find the effect of storage of test specimens, the method of capping, the effect of moisture when tested, the effect of age, the effect of time of removal from mold, the strength of concrete specimens cut from various portions of a structural member or from a pavement to determine the effect of different elements entering a mixture of concrete, and lastly, to find the effect of various sands on the effect of concrete. Address Dean C. R. Richards, Engineering Experiment Station, University of Illinois, Urbana, Ill.

*Fuels, Gas, Tar and Coke B3-21.* Ignition Point of Fuels. The ignition point of fuels is being investigated by Prof. H. H. Stoek and R. W. Arms by observing the action of coal when gradually heated. Address Dean C. R. Richards, Engineering Experiment Station, University of Illinois, Urbana, Ill.

*Fuels, Gas, Tar and Coke B4-21.* Dewatering Coal Slime. H. F. Yancy and Thomas Fraser, under the direction of the U. S. Bureau of Mines, are investigating the dewatering of coal slimes, conducting experiments at the filter plant in Urbana in connection with the sludge work of the state water supply. Address Dean C. R. Richards, Engineering Experiment Station, University of Illinois, Urbana, Ill.

*Fuels, Gas, Tar and Coke B5-21.* Coal Washing. H. F. Young and Thomas Fraser are investigating the washing of coals of different kinds and under different conditions and also the separation of pyrite and organic sulphur by washing with jigs and tables. Address Dean C. R. Richards, Engineering Experiment Station, University of Illinois Urbana, Ill.

*Fuels, Gas, Tar and Coke B6-21.* Sliding Friction. Professors Stoek and Holbrook are determining the sliding friction of bituminous coal and the subsidence used for chutes in conveying coal. Address Dean C. R. Richards, Engineering Experiment Station, University of Illinois, Urbana, Ill.

*Heat B21-21.* Buried Pipe. An investigation to determine the temperature gradient of heat flow from steam pipe buried in ground to surrounding earth in connection with the fellowship of Ric-wil Company is being continued at the University of Michigan. Thermocouples are distributed in a plane normal to the pipe and one or two readings are taken a day. At the same time the pressure and quality of the steam is observed. University of Michigan, Ann Arbor, Mich. Address J. E. Emswiler.

*Machine Design B5-21.* Stresses in Boiler Heads. Prof. G. A. Goodenough is investigating the stresses in boiler heads. Address Dean C. R. Richards, Engineering Experiment Station, University of Illinois, Urbana, Ill.

*Mechanics B4-21.* Web Stresses in Beams. Prof. A. N. Talbot and others are investigating the web stresses in beams to determine the best method of reinforcing beams to take diagonal tension stress. Stirrups and bent-up bars are used in various proportions, amounts and spacings, tests being made with steel gages on both samples and restrained beams. Address Dean C. R. Richards, Engineering Experiment Station, University of Illinois, Urbana, Ill.

*Mechanics B5-21.* Reinforced-Concrete Columns. An investigation by the use of the strain gage on the reinforcement to determine the strains in the reinforcement and the action of the spiral reinforcement. The investigation will include the effect of pitch, spiral length of column, eccentricity, richness of concrete and longitudinal reinforcement as well as frictional resistance of granular material restrained by hooping. Address Dean C. R. Richards, Engineering Experiment Station, University of Illinois, Urbana, Ill.

*Railway Rolling Stock and Accessories B4-21.* Journal Friction. A considerable amount of data has been collected on friction of railroad-car journals in relation to and as a component part of the resistance of trains. The investigation will include the analysis of existing information and the analysis of data possessed by the Railway Engineering Department of the University of Illinois as well as additional test results obtained by the railway electrical test car. Address Dean C. R. Richards, Engineering Experiment Station, University of Illinois, Urbana, Ill.

*Railway Rolling Stock and Accessories B5-21.* Trolley Cars. The method of reducing the pounding of trolley cars and the possibility of increasing the pressure between the trolley wire and collector with increased speed of car has been undertaken by J. K. Tathill under the direction of Prof. J. N. Snodgrass. This work is being done with the electrical test car of the University of Illinois. Address Dean C. R. Richards, Engineering Experiment Station, University of Illinois, Urbana, Ill.

*Railway Rolling Stock and Accessories B6-21.* Tractive Effort. An investigation has been begun under the direction of Prof. J. N. Snodgrass to determine the values of locomotive tractive effort. Address Dean C. R. Richards, Engineering Experiment Station. University of Illinois, Urbana, Ill.

*Transportation B1-21.* Wire-Rope Fastenings. The strength of wire-rope fastenings including clips, clamps, sockets and other devices, is to be investigated at the Ohio State University for the Director of Safety of the State of Ohio. Ohio State University, Columbus, Ohio. Address Prof. W. T. Magruder.

## C—Research Problems

The purpose of this section of Engineering Research is to give notes of a personal nature regarding the personnel of various laboratories, methods of procedure for commercial work or notes regarding the conduct of various laboratories.

*Transportation C1-21.* Wire-Rope Fastenings. To aid the Engineering Experiment Station of the Ohio State University to publish a report on the Strength of Wire Ropes and Their Fastenings, information regarding results of tests or information regarding reports on this subject is greatly desired. The questions which have arisen are as follows:

1 What are the relative strengths of wire-rope eyes, or loops, made up with clips and clamps, and of wire ropes with sockets of various kinds and constructions, as compared with the rope itself, either spliced or tested over sheaves?

2 Sockets are usually considered to be a permanent fastening, but when should clips be used rather than clamps?

3 How should they be applied? How tightly should they be drawn up?

4 What effect has the size of the thimble on the strength of the rope?

5 How many fastenings should be used on each loop or eye?

Ohio State University, Columbus, Ohio. Address Prof. W. T. Magruder.

## D—Research Equipment

The purpose of this section of Engineering Research is to give in concise form notes regarding the equipment of laboratories for mutual information and for the purpose of informing the profession of the equipment in various laboratories so that persons desiring special investigations may know where such work may be done.

*University of Alabama E1-21.* The Legislature of the State of Alabama has created a special School of Mines fund of $25,000 per year for four years to be used in coöperative work with the U. S. Bureau of Mines, the Bureau of Mines to provide equal funds. As a result a thoroughly modern mining and ore-dressing laboratory for the School of Mines of the University of Alabama has been installed. Five fellowships are to be offered during the coming year. These are open to graduates of universities and engineering schools. The value of each fellowship is $540 per year of nine months. The following subjects are to be investigated during the coming year:

1 Beneficiation of iron ores.

2 The preparation, treatment and uses of non-metallic minerals such as barite and ocher in industries other than ceramic or chemical industries.

3 Metallurgical coke.

University of Alabama, University, Ala. Address Prof. H. D. Pallister.

## E—Research Personnel

The purpose of this section of Engineering Research is to give notes of a personal nature regarding the personnel of various laboratories, methods of procedure for commercial work or notes regarding the conduct of various laboratories.

## F—Bibliographies

The purpose of this section of Engineering Research is to inform the profession of bibliographies which have been prepared. In general this work is done at the expense of the Society. Extensive bibliographies require the approval of the Research Committee. All bibliographies are loaned for a period of one month only. Additional copies are available, however, for periods of two weeks to members of the A.S.M.E. These bibliographies are on file at the office of the Society

*Transportation F1-21.* Wire-Rope Fastenings. A bibliography of two pages on Wire Ropes, Clips, Clamps and Sockets. Search 3411. Address Arthur M. Greene, Jr., Rensselaer Polytechnic Institute, Troy, N. Y.

# CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Department of MECHANICAL ENGINEERING are solicited. Contributions particularly welcomed are discussions of papers published in this Journal, brief articles of current interest to mechanical engineers, or suggestions from members of The American Society of Mechanical Engineers as to a better conduct of A.S.M.E. affairs.

## The Question of Entropy

TO THE EDITOR:

Professor Goldman's demonstration on page 621 of MECHANICAL ENGINEERING for September that "Entropy is a complete error" is interesting but not convincing. In his notation he says that $H$ denotes the heat energy. If we knew precisely what heat energy is under consideration, it would be easy to point out the fallacy in the demonstration; not knowing which of the various heat energies $H$ stands for, we must examine each of the possible cases.

In thermodynamics there are three thermal magnitudes that demand attention:

1 $Q$, the heat absorbed by a system when it changes state
2 $U$, the intrinsic energy of the system
3 $I, = V + (pV/778)$.

This last quantity, $I$, is one of the so-called thermodynamic potentials devised by Duhem, Gibbs, and others in the consideration of the equilibrum of thermodynamic systems. The intrinsic

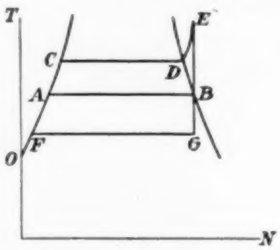



FIG. 1

energy $U$, which is due to the molecular motion and molecular configuration of the system, is fixed by the state of the system; that is, the change of $U$ between two states is independent of the path followed. Evidently, therefore, since the product $pV$ is fixed by the state, the value of the potential function $I$ is likewise determined solely by the state of the system.

On the other hand, the quantity of heat $Q$ absorbed by the system in a change of state depends on the path. Thus:

$$Q = \text{increase of energy } u + \text{external work}$$

and since the external work varies with the path, $Q$ likewise depends on the path.

It is most unfortunate that the name "heat content" is often given to the potential function $I$. This name gives rise to endless confusion in the minds of students and possibly in the minds of professors also. The association of $Q$ and $I$ in the case of saturated steam is probably responsible for the troublesome situation. Professor Goldman says that the heat content (that is, the value of $I$) of steam at a pressure of 100 lb. is fixed and definite, irrespective of how the steam was produced. This statement is strictly true; but it is *not* true of the heat $Q$ absorbed in the change from water at 32 deg. to steam at 100 lb. The accompanying figure illustrates this point.

If, as usual, the water is heated and vaporized at constant pressure the area between $QAB$ and the $N$-axis represents the heat absorbed and also the change of $I$ from water at 32 deg. to saturated steam in the state $B$; or, neglecting the small value of $I$ at point $O$, the area under $OAB$ represents the value of $I$ (the heat control) at state $B$. But the same state $B$ may be attained by some other path as $OCDEB$ or $OFGB$. In the first of these the water is boiled at a higher pressure, then superheated as indicated by $DE$ and then expanded adiabatically, as shown by $EB$. The heat absorbed in this case is represented by the area under $OCDE$. Or, if the water is vaporized at a lower pressure along $FG$, and the mixture in the state $G$ is compressed adiabatically from $G$ to $B$, the heat absorbed is represented by the area under $OFG$. Thus the $Q$ absorbed between $O$ and $B$ may have different values depending on the character of the process, but the $I$ at point B is fixed and definite and is represented by one area, that under $OAB$.

The object of the preceding discussion is to emphasize the point that there is no necessary connection between the so-called heat content of a system and the heat $Q$ absorbed in some change of state of the system. In just one case, that in which constant pressure is maintained in the system, the change of $I$ gives the heat absorbed; in all other cases the two magnitudes have different values.

Professor Goldman says that $H$ denotes the heat energy. It may be assumed that his $H$ stands for either $Q$ or $I$. In the former case his definition of entropy, namely $dN = dQ/T$, agrees with the authorities from Clausius down. If such is the case, the alleged functional relation $N = f(H,E)$, which translated into the customary notation becomes $N = f(Q,T)$, simply does not exist. Since $Q$ depends upon the path it is not a function of the variables that define the state, and to say that any of these variables is a function of $Q$ is nonsense. Hence, with the proper definition of entropy, the mathematical discussion under section ($a$) breaks down completely.

But from the discussion ($b$) it seems probable that Professor Goldman has confused $Q$ and $I$, and has used $dI$ instead of $dQ$ in his definition. In this event the mathematical discussion is correct, and the entropy that "is an error" is a new, special brand of entropy defined by the equation $dN = dI/T$. Thus Professor Goldman demonstrates that his particular entropy, not the time-honored entropy of Clausius and Thomson, does not behave in accordance with the established rules. In other words, he knocks down a man of straw that he has himself constructed.

G. A. GOODENOUGH.

Urbana, Ill.

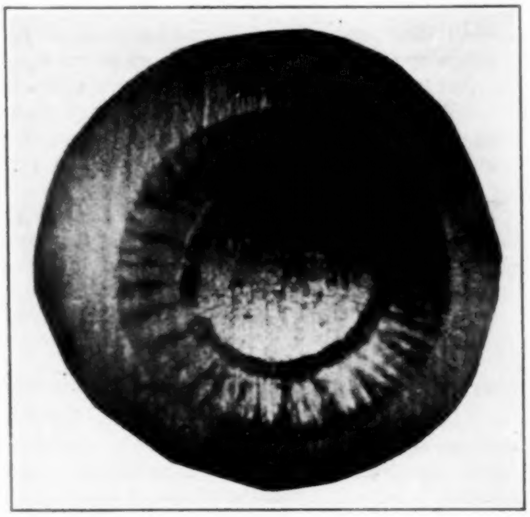
## The Hardness Testing of Metals

TO THE EDITOR:

The writer has just read, with considerable interest, in the July issue of MECHANICAL ENGINEERING the report of a committee of the Engineering Division of the National Research Council on The Hardness Testing of Metals, and having spent some time on the hardness testing of steel, both in the annealed and hardened state, feels that comment will not be out of order. To all of those who are connected in any way with the acceptance of raw material upon its entering the shop or of the same material after different operations throughout manufacturing there comes a time (particularly in the fabrication of high-carbon or alloy, steel products which are to be more or less highly stressed or abraded in operation) when the acceptance or rejection of those parts is absolutely dependent upon some method of hardness testing, and it is at this time that the inadequacy of our present methods of determining hardness is most forcefully brought home, particularly if the material is near the dividing line between "hard" and "soft." That, it is almost universally conceded, is a fairly well-established fact.

The suggestion of Mr. Hultgren of the use of etched balls to bring out more clearly the indentations made by the Brinell testing machine, may at first seem to be a decided step for the better, and undoubtedly on some grades of steel this will give satisfactory results, but on extremely hard, tough alloy steels the etched ball has little, if any, effect in making readings easier unless etched very

deep. The writer has tried this where the indentation of a polished ball was vague, and although the imprint of the etched ball was plain at the bottom of the crater it grew less distinct at the edges, in many cases being imperceptible. If the ball is etched very deeply, say three or five minutes in concentrated $HNO_3$, then the print is more clear, but the value of the test has been lost if accuracy is to be adhered to. In connection with this the writer has tried several methods, some of which work satisfactorily, namely etching the specimens, coloring the ball with various substances such as carbon or prussian blue, or so polishing the specimen that very fine streaks are left on the surface, which, when struck by light rays, will stand out in relief. It may be argued by some that etching the specimens will tend to break down the surface; however, of the two evils it is better to break down the surface of the sample than that of the ball, for the depth of indentation is reached when an equilibrium is established between the pressure exerted by the ball and the resistance to penetration offered by the metal, and this



Micrograph Showing Effect of Bluing the Ball in Hardness Testing

is reached at the end and not at the beginning of the travel of the ball into the metal.

In using some coloring substance prussian blue seems most satisfactory, for as the ball penetrates the sample the fluid is squeezed to the boundary and in no way interferes with the test. The accompanying micrograph illustrates this. It is not offered as an ideal sample of indentation, but to show the effect of bluing the ball. In this connection it is of interest to note that all of the bluing has not been squeezed to the boundary, which would indicate that the ball was not absolutely spherical. On investigation this was found to be true, for the ball (10 mm. in diameter) was measured before loading and while under a load of 3000 kg. it was found to be some 0.0004 in. larger on an equator equidistant from the points of contact with the specimen and plunger. This explains the fact that the bluing was not all forced out, for while under pressure the ball fits the indentation, but as soon as the load is released the ball assumes its original form and no longer fits the crater except at a small area at the bottom, allowing the bluing to creep back. This accounts for the possible error of reading width rather than depth of indentation in determining hardness values and speaks decidedly in favor of the depth method.

Referring to the sections of the report dealing with the Brinell meter and Morin hardness-testing apparatus, the only advantage these instruments have is their portability, which of course is the reason for their development. There is certainly more chance for error, for, first a standard is determined in the regular way and then a sample tested and compared with that standard. To say that for very hard steels the Brinell method is more or less guesswork would be making a rather broad statement, but it is an established fact that a hardened ball can be forced into a flat surface, even though the surface is harder than the ball; furthermore, there is no present absolute method of determining hardness or softness, it being a matter of comparison, and there can easily be variation enough in ball hardness, even though the balls be specially selected, to give variant results and incorrect readings.

R. H. Coolidge.

Chicago, Ill.

## What of the Young Engineer?

To the Editor:

Prominent men in the engineering profession are today turning their attention to the various industrial problems now confronting the nation. An investigating committee, headed by Mr. J. Parke Channing and L. W. Wallace, has recently completed an industrial survey that was nation-wide. The gentlemen conducting this survey have gone over the ground in a thorough and painstaking manner and have gotten results that are admittedly accurate. Their report, among other things, places the responsiblity for the elimination of business waste, depression, and general debility upon management.

Admitting that lack of knowledge on the part of management is the prime cause of wasteful, inefficient running and even failure in business, does it not show that there is a general lack of training in this most important phase of industrial activity? It would seem that the heads of these concerns, the general executive staff, have not had the proper grounding in the rudiments and fundamentals of executive knowledge. The remedy is obvious—select the right men for the governing heads of the particular industry in question and let them renovate and instill new life and energy into it. But men of this type are not easily procurable, nor can they be trained at a moments' notice. The few national geniuses in this line need not be reckoned with in this discussion. Where are men who possess the necessary qualities for such a position to be found?

Our technical colleges and our universities are turning out just such men year after year; turning out men who have been trained to think for themselves along orderly lines. The curriculum of these schools endeavors to give to all their students as broad an industrial education as can possibly be combined with the necessary purely technical knowledge that they must assimilate. It would seem, then, that the technical graduate is not only the logical man to train for such a position, but also practically the only candidate with a full complement of the necessary mental equipment.

The cause of the waste has been found, a preventive measure for the future is at hand, but is it being used? Not if we are to take into account the situation as it stands today. Vast numbers of recent technical graduates are today without positions, without a chance to get one. These men have put in four or five years, as the case may be, of the hardest grind. They have, for the most part, made great sacrifices of time and money; they have worked, scrimped and saved for their education because of their determination to fit themselves for a career. Now that the constructive work is finished and ready for use, they are worth—if the present attitude of the older engineers and business men is to be considered—*exactly nothing*.

Why, then, do prominent engineers make exhaustive investigations and reports upon business diseases and yet have no thought for remedying a condition which will further aggravate the situation? Machinery improvements may speed up production, new cost systems and routing methods may cut costs and time of handling merchandise, but in the last analysis brains and human energy are the motive power behind them all. Why try to doctor the disease without removing one of the chief causes? What the country's business needs is more trained men and plenty of them.

The potential creative power, the potential wealth of knowledge and intensive training that is stored up in the brains of these young men, if allowed to go to waste through lack of opportunity, will be a staggering loss to the engineering field. Engineers view, with grave concern and some alarm, the diminishing of our oil reserves, our forests and our coal mines; but they allow this waste of human energy and ability of the highest order to go unchecked. This enormous waste, of graver consequence than all the others put together, is still allowed to go on because engineers do not perceive, or will not perceive, the far-reaching ill effects of such a policy.

Does the present condition of affairs indicate that there is no further need for the technical graduate, at least for the next year

(*Continued on page 697*)

# MECHANICAL ENGINEERING

**A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of**

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C 55 The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.


## Powdered Coal as a Boiler Fuel

WHILE powdered coal has been burned under boilers for over twenty years, the installations have consisted mainly of small units designed for burning coal on grates which were changed over, with only minor alterations, to burn this new form of fuel. These rebuilt installations, however, were not without their value, since they demonstrated very clearly that for best results with this type of fuel a design of furnace was required which differed radically from that used with stoker- or hand-fired boilers.

Edwin B. Rickets

The first large central station designed for the exclusive use of powdered coal is the Lakeside plant of the Milwaukee Electric Railway and light Company and great credit is due Mr. John Anderson, chief engineer of the company, for his pioneer work in this field and his courage in making such a radical departure in power-station design.

The tests on No. 8 boiler at the Lakeside plant, made by Henry Kreisinger and reported elsewhere in this issue, have clearly demonstrated that efficiencies are possible with this fuel fully equal to those obtained in the best oil-burning plants and 2 or 3 per cent better than has been done with the best stoker installations. The difference in best test efficiencies between powdered coal and stokers would not be sufficient to overcome the handicap of extra preparation costs with powdered coal, but, due to its greater ease of regulation, it is much easier to maintain with powdered coal—as with oil—efficiencies in regular operation closely approaching those obtained on tests than with stokers. The difference in efficiency in regular operation would probably be in the neighborhood of 6 or 7 per cent in favor of powdered coal.

Of the problems which confronted the would-be user of powdered coal some years ago, many are approaching solution. The efficiencies obtained at Lakeside leave little to be desired, and while as high capacities have not been realized as with stokers, it has been demonstrated that capacity is largely a matter of furnace volume and draft. The problem of driers has for most cases been eliminated, as evidenced by the fact that the River Rouge plant of the Ford Motor Company is operating satisfactorily on coal having 15 per cent moisture without driers. Considerable progress has been made in reducing the fineness of grinding, and while we may never reach our ultimate aim of burning crushed coal in suspension, the indications are that in the future we will burn much coarser coal than is thought possible now. On the matter of grinding costs there is much to be desired in the data available, figures from various plants running all the way from 30 cents to $3 per ton. It is hoped that costs on some of the modern grinding plants which have been installed in the last year or two will be published as soon as the plants have been operating long enough to make the data reliable. While the fact that about 90 per cent of the ash in the coal passes out the stack may not be a problem in some industrial communities, it is a very vital one in our large cities. Experiments are now being made to catch this material, but so far no satisfactory means has been perfected.

That powdered coal as a boiler fuel is here and here to stay, few will question; that it will eliminate other means of burning coal is hardly possible. There is undoubtedly a field where this fuel will prove the best, as there are others where stokers, oil or gas will reign supreme. When only very low-grade coal which is burned with great difficulty on stokers is available and where coal is very high in price, powdered coal would seem to have a decided advantage over stokers. Where good stoker coal is available at a low price, the advantage is with the stokers. With eastern seaboard conditions—a good grade of coal available at a medium price—the best method of burning fuel becomes a matter for very close calculation. The extent of the place which powdered coal will occupy in the future none can foresee, but the problem of the engineer in considering this fuel in the same as that with all other types of fuel, namely, the careful balancing of efficiency against the cost of obtaining that efficiency. Edwin B. Ricketts.

## Engineers Conducting Pre-College Education

IT is to be hoped that no engineer, whether specially interested in the subject of education or not, will fail to read the article in the *Atlantic Monthly* for July entitled Mastering the Arts of Life. The article is an account of the efforts of Col. E. A. Deeds, Mr. C. F. Kettering and Mr. Arthur E. Morgan to break away from the conventional methods of education for the young, whether as a preparation for "life" or for college, and of the results so far achieved.

Colonel Deeds needs no introduction to our readers, and Mr. Kettering also is a man of achievement in the automotive field, while Mr. Morgan is the engineer who has directed the colossal work of flood prevention in the Miami Valley in Ohio.

Starting with the desire only to provide for the primary education of their own children in a way which they believed would be a much better preparation for real life in a real world, than is afforded by the standard pedagogic methods of the primary, grammar and high schools of the country, this school has grown into what appears to be an institution and it seems to answer thoroughly and satisfactorily many of the problems of those who, having children to train for a life of honorable usefulness, feel that the standard school methods do not meet the requirements of the present time, and are at a loss as to what to do about it.

All the methods followed in this school seem to be as different from the usual pre-college educational methods as could well be yet its graduates are really educated in the best sense of the word and if they wish are admitted upon certificate to colleges.

No condensation of the short article in the *Atlantic* can do it justice; but, suffice it to say that all the usual tests by means of examinations are eliminated and new standards are set up—such standards as the pupils will be judged by in the actual world in which their lives are to be spent.

Referring to the earlier period, before the elaboration of the modern school system, when the farm boy "had but three months of schooling in the year; which left nine months for him to get an education," it is declared that we have copied our school methods largely from the Germans or the classic English schools and have crowded out the American sort of education. "To make Americans you must inculcate and strengthen American traits. That, our schools are not doing. Initiative is a prime American trait, but our schools teach conformity. We are an ambitious people, but

our schools tend to delegate athletics to specialists. The American is many-sided, but our educational system aggrandizes only one side of the mastery of living. Business shrewdness is another distinctive American trait, but our education does not give us business power. We believe in democracy and self-government, and our schools are autocracies. We are a religious people, and our schools are unreligious, repressing the spiritual element in education through fear of offending sectarian prejudices."

Aside from the interest this article has for every intelligent person interested in education, it possesses special interest for engineers as an account of how competent engineers have applied the methods of the engineer to educational problems: i.e., sat down and carefully considered what training a young person should have to best qualify him, not solely for making money, or for "being successful" in the ordinarily accepted sense of that term, but for that real success which comes from not alone the ability to make money, but the ability to render service and to live a full and well-rounded life of usefulness and of satisfactory achievement as an individual and as a citizen member of coöperative society. The school has been designed to accomplish that object and in its design the traditional methods of pedagogy have been almost entirely discarded and the result is most excellent as regards the physical well-being and the mental and moral development of its very fortunate pupils.

This school has also a very interesting relation to the paper by Mr. H. E. Miles, which appeared in the August number of Mechanical Engineering, and which has attracted a great deal of attention as a masterly presentation of points in which the standard educational methods fail in their adaptation to present-day conditions, and offers suggestions for improvements such as would scarcely occur to anyone not acquainted by experience with what most of the worlds' producers really need by way of education to enable them to lead the most useful and successful lives.

## The Airship Disaster

When the Quebec Bridge failed the general feeling in the engineering profession was that the disaster was due not to lack of competence on the part of the designers and erectors, but rather to a lack of knowledge of thebehavior of structures of such size.

In the early days of ore transportation on the Great Lakes there were several failures of steel ore boats which simply broke in the middle and plunged to the bottom like a stone. This again, was ultimately found to be due to peculiar, and, until then, unknown stresses to which vessels of such great length were subjected in certain parts of the Great Lakes. Once this became known, a comparatively simple change of design was made and ore transportation became safe.

There is good reason to believe that the fundamental cause of the airship disaster lies also in lack of knowledge of vital elements underlying the design of large airships. It is, at times, difficult to realize how slight our knowledge of airship engineering really is. We are dealing with structures 600 to 700 ft. long, weighing in the air next to nothing. At both ends of these immensely long structures we have operable planes (rudders and elevators) of very considerable size, presenting resistance to the air equal to a pressure estimable in tons, which, with a leverage of some 300 ft., must impose tremendous stresses amidships. What these stresses are we do not know, nor have we either experimental or mathematical bases for computation. This is particularly so, as we do not even know to what extent the theoretically rigid dirigible is capable of flexure.

Such a situation would have been bad enough if we were dealing with materials with whose behavior we are familiar, but we are not. The main resistance parts of the dirigible are constructed of the so-called "duralumin"—an alloy of aluminum and copper, or aluminum and zinc, or all three of them. Duralumin is, however, a new alloy, practically a "war baby," and we have only scant knowledge as to its behavior and next to no knowledge as to its ability to withstand repeated stresses—something of particularly great importance in a structure that is vibrating like a string all the time. In airship design we have therefore to meet unknown stresses with a material of unknown qualities, which would be bad enough in itself but is stupendously aggravated by another circumstance, and that is the very low factor of safety employed in airship construction.

In a bridge, an ore boat, an automobile, generous factors of safety are used wherever there is doubt as to the stresses to which a member is likely to be submitted, because there is no vital gain outside of the cost consideration, which should be secondary in using excessively light members. But this is not so in an airship. If the latter is designed to fly across the Atlantic it must carry a certain weight of gasoline, oil and useful load, and every pound of these supplies reduces by a pound the weight of the metal that can be put into the structure, and hence the factor of safety, with the result that members one sixteenth to one eighth of an inch in thickness are by no means uncommon in dirigible construction; and members of such slender dimensions in duralumin, under the tremendous stresses they are called upon to withstand, no longer possess a factor of safety but rather a factor of daring.

The airship has a certain military value, and in a war structure the lack of sufficient safety may not be considered a vital objection to its employment. For peace purposes the airship can probably be also made sufficiently safe after enough time and money have been spent in experimental work. It may be of interest to note that out of about fifty big dirigibles built so far at least one-third have met a violent end.

It was evidently from such a point of view as that, that the National Advisory Committee for Aeronautics passed a resolution recommending the government to continue its work on dirigibles, and to purchase for this purpose a discarded German Zepplin. A more thorough investigation of the properties of duralumin, its heat treatment, "ageing," behavior under alternating stresses etc., might also be of interest, and not for the design of dirigibles airships only.

## The Lakeside Plant Pulverized-Fuel Tests

Much interest was aroused at the A.S.M.E. Spring Meeting in Chicago by the high boiler efficiencies reported by Mr. Henry Kreisinger as having been obtained in tests at the Lakeside Plant of the Milwaukee Electric Railway and Light Company, where pulverized coal is exclusively used as fuel. These tests and an additional one, which are commented on editorially in this issue, have been recalculated with the B.t.u. determinations made by the Bureau of Mines and are printed below, together with further particulars regarding the plant which have been kindly supplied by Mr. Kreisinger for publication.

SUMMARY OF RESULTS OF FIVE BOILER TESTS WITH PULVERIZED ILLINOIS COAL. TESTS MADE ON BOILER NO. 8, LAKESIDE STATION OF THE MILWAUKEE ELECTRIC RAILWAY AND LIGHT CO.

| Test No. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Duration, hr. | 42.33 | 23.97 | 19.92 | 24.20 | 24.17 |
| *Coal as Fired:* | | | | | |
| Per cent through 100 mesh | 89.2 | 90.8 | 90.5 | 92.2 | 90.5 |
| Per cent through 200 mesh | 67.7 | 68.7 | 69.1 | 70.5 | 66.7 |
| Moisture content, per cent | 2.25 | 3.56 | 3.59 | 5.24 | 5.61 |
| Volatile matter, per cent | 36.60 | 36.48 | 35.66 | 36.30 | 35.85 |
| Fixed carbon, per cent | 49.60 | 48.33 | 48.70 | 46.10 | 47.16 |
| Ash, per cent | 11.55 | 11.63 | 12.05 | 12.36 | 11.38 |
| Sulphur, per cent | 2.26 | 2.74 | 2.28 | 3.91 | 3.39 |
| Hydrogen, per cent | 4.97 | 5.18 | 5.01 | 5.10 | 5.06 |
| Carbon, per cent | 68.88 | 67.20 | 66.22 | 63.44 | 65.41 |
| Calorific value, B.t.u. | 12321 | 12022 | 11917 | 11483 | 11661 |
| Total fuel fired, lb. | 253161 | 233477 | 190334 | 160881 | 274640 |
| Fuel fired hourly, lb. | 5980 | 9740 | 9560 | 6650 | 11350 |
| Fuel fired hourly per cu. ft. combustion space, lb. | 0.85 | 1.39 | 1.36 | 0.95 | 1.62 |
| *Ash and Refuse:* | | | | | |
| Carbon in second- and third-pass refuse, per cent of coal fired | 3.60 | 5.06 | 5.06 | 5.31 | 7.17 |
| Carbon in uptake dust, per cent | 6.26 | 5.09 | 3.39 | 2.82 | 5.95 |
| Unburned carbon per lb. coal, per cent | 0.45 | 0.45 | 0.40 | 0.40 | 0.74 |
| *Ash Account:* | | | | | |
| From bottom of furnace, lb. | 6240 | 6414 | 5230 | 4420 | 1000 |
| From second and third pass, lb. | 13565 | 12236 | 9278 | 8260 | 12270 |
| Determined from dust-collector data, lb. | 10580 | 8640 | 8632 | 7290 | 18120 |
| *Air:* | | | | | |
| Temp. of air entering furnace, deg. fahr. | 86 | 89 | 91 | 104 | 93 |
| Pressure of air at feeders, in. of water | 11.0 | 12.2 | 13.6 | 12.2 | 13.6 |
| Air entering with coal, lb. per lb. coal | 2.05 | 1.25 | 1.27 | 1.85 | 1.03 |
| Air entering at burners, lb. per lb. coal | .... | .... | .... | 2.07 | .... |
| Air through hollow wall, lb. per lb. coal | .... | .... | .... | 5.64 | .... |
| Excess air in flue gases, per cent | 13.3 | 21.9 | 21.2 | 10.7 | 25.2 |

| | | | | | |
|---|---|---|---|---|---|
| *Flue Gas:* | | | | | |
| Carbon dioxide in fourth pass, per cent | 15.8 | 14.6 | 14.7 | 16.0 | 14.1 |
| Oxygen in fourth pass, per cent | 3.3 | 4.6 | 4.6 | 3.3 | 5.2 |
| Carbon monoxide, fourth pass, per cent | 0.05 | 0.0 | 0.03 | 0.0 | 0.09 |
| Carbon dioxide entering economizer per cent | .... | 12.6 | 12.6 | 14.4 | 11.5 |
| Carbon dioxide leaving economizer, per cent | 10.4 | 11.9 | 12.0 | 13.2 | 10.8 |
| Lb. dry gas per lb. coal leaving boiler | 11.04 | 11.63 | 11.37 | 10.06 | 11.56 |
| Lb. dry gas per lb. coal entering economizer | ..... | 13.36 | 13.16 | 11.14 | 14.10 |
| Lb. dry gas per lb. coal leaving economizer | 16.45 | 14.11 | 13.80 | 12.07 | 15.01 |
| Temp. flue gases leaving boiler, deg. fahr. | 434 | 475 | 482 | 430 | 496 |
| Temp. flue gases entering economizer, deg. fahr. | 388 | 400 | 424 | 400 | 431 |
| Temp. flue gases leaving economizer, deg. fahr. | 168 | 196 | 205 | 204 | 251 |
| *Draft:* | | | | | |
| At furnace, in. of water | 0.017 | 0.19 | 0.16 | 0.045 | 0.206 |
| In fourth pass, in. of water | 0.314 | 1.11 | 1.185 | 0.39 | 1.40 |
| Entering economizer, in. of water | 0.424 | 1.23 | 1.28 | 0.40 | 1.66 |
| Leaving economizer, in. of water | 0.525 | 1.67 | 1.72 | 0.51 | 2.38 |
| *Steam and Water:* | | | | | |
| Steam pressure, lb. absolute | 276 | 280 | 280 | 276 | 281 |
| Degrees of superheat | 137.4 | 180.8 | 186.8 | 118.4 | 178.6 |
| Total water fed to boiler, lb. | 2260018 | 2012452 | 1615530 | 1393250 | 2228514 |
| Water fed to boiler per hr., lb. | 53390 | 83953 | 81121 | 57572 | 92202 |
| Water evaporated per lb. coal, lb. | 8.92 | 8.62 | 8.49 | 8.66 | 8.12 |
| Heat absorbed per lb. water, boiler and superheater | 1149.6 | 1151.0 | 1158.4 | 1132.0 | 1146.6 |
| Temp. feedwater entering economizer, deg. fahr. | 126 | 129 | 124 | 126 | 127 |
| Temp. feedwater entering boiler, deg. fahr. | 168 | 192 | 188 | 175 | 195.4 |
| *Rates of Heat Absorption:* | | | | | |
| Per cent rating developed | 137 | 215 | 209 | 147 | 236 |
| Horsepower developed | 1833 | 2886 | 2798 | 1946 | 3156 |

| Test No. | 1 | | 2 | | 3 | | 4 | | 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Heat Balance—Boiler:* | B.t.u. | Per cent | B.t.u. | Per cent | B.t.u. | Per cent | B.t.u. | Per cent | B.t.u. | Per cent |
| ▶ Heat absorbed by boiler and superheater | 10260 | 83.3 | 9924 | 82.6 | 9835 | 82.5 | 9803 | 85.4 | 9309 | 79.8 |
| (*a*) Loss—carried away in dry gases | 928 | 7.5 | 1086 | 9.0 | 1076 | 9.0 | 794 | 6.9 | 1130 | 9.7 |
| (*b*) Loss—steam from burning hydrogen | 511 | 4.2 | 524 | 4.3 | 506 | 4.3 | 480 | 4.2 | 488 | 4.2 |
| (*c*) Loss—steam from moisture in coal | 27 | 0.2 | 43 | 0.4 | 44 | 0.4 | 62 | 0.5 | 69 | 0.6 |
| (*d*) Loss—steam from moisture in air | 10 | 0.1 | 10 | 0.1 | 13 | 0.1 | 21 | 0.2 | 23 | 0.2 |
| Loss—by carbon monoxide | 22 | 0.2 | 0 | 0.0 | 14 | 0.1 | 0 | 0.0 | 42 | 0.4 |
| Loss—carbon in ash and flue dust | 66 | 0.5 | 62 | 0.5 | 59 | 0.5 | 59 | 0.5 | 108 | 0.9 |
| Loss—radiation | 166 | 1.4 | 125 | 1.1 | 125 | 1.1 | 147 | 1.3 | 114 | 1.0 |
| Loss—errors and unaccounted for | 331 | 2.6 | 248 | 2.0 | 245 | 2.0 | 125 | 1.0 | 378 | 3.2 |
| Total | 12321 | 100.0 | 12022 | 100.0 | 11917 | 100.0 | 11491 | 100.0 | 11661 | 100.0 |
| *Heat Balance—Economizer:* | | | | | | | | | | |
| Total heat supplied—items (*a*), (*b*), (*c*) and (*d*) above | 1476 | 12.0 | 1663 | 13.8 | 1639 | 13.8 | 1357 | 11.8 | 1710 | 14.7 |
| Heat absorbed by economizer | 375 | 3.0 | 543 | 4.5 | 543 | 4.5 | 432 | 3.8 | 556 | 4.8 |
| Loss—dry gases delivered from boiler | 219 | 1.8 | 301 | 2.6 | 314 | 2.6 | 244 | 2.1 | 444 | 3.8 |
| Loss—air leaking into economizer | 107 | 0.9 | 63 | 0.5 | 67 | 0.6 | 49 | 0.4 | 132 | 1.1 |
| Loss—water vapor | 483 | 3.9 | 506 | 4.2 | 491 | 4.1 | 493 | 4.3 | 505 | 4.3 |
| Total heat accounted for | 1184 | 9.6 | 1413 | 11.8 | 1415 | 11.8 | 1218 | 10.6 | 1637 | 14.0 |
| Radiation and unaccounted for | 292 | 2.4 | 250 | 2.0 | 224 | 2.0 | 139 | 1.2 | 73 | 0.7 |
| Heat absorbed by boiler and economizer | 10635 | 86.3 | 10467 | 87.1 | 10378 | 87.0 | 10235 | 89.1 | 9865 | 84.6 |

PRINCIPAL DIMENSIONS OF BOILER AND ECONOMIZER AT THE LAKESIDE PLANT

*Boiler.*—Edgemoor four-pass with 563 4-in. tubes 20 ft. long (15 high by 37 and 38 wide), and 5 steam drums. Total heating surface, 13,060 sq. ft.

*Water Screen.*—22 4-in. tubes each with an average exposed length of 13³/₄ ft.; total heating surface of exposed part of tubes, 320 sq. ft. Total heating surface of boiler and water screen, 13,380 sq. ft.

*Superheater.*—Foster.

*Economizer.*—Sturtevant, with 528 4¹/₂-in. O. D. cast-iron tubes 12 ft. long (12 wide by 44 long); provided with a steam-turbine-driven induced-draft fan.

*Furnace.*—Average width, 22 ft.; average length, 14 ft.; height under tubes, 25 ft.; height under arch, 22 ft.

*Burners.*—6 flat Lopulco burners used; air supplied to feeders and burners under pressure of 12 in. water.

## Peter Cooper Hewitt Dies

Peter Cooper Hewitt, one of America's well-known inventors and engineers, died in Paris on August 25, 1921, from pneumonia following an operation. Mr. Hewitt was born in New York on March 5, 1861, and was educated at Stevens Institute and at Columbia University, being graduated as a mechanical and electrical engineer. He received the honorary degree of Sc.D. from the latter institution in 1903 and from Rutgers College in 1916.

In addition to his inventions Mr. Hewitt took an active interest in a number of industrial corporations and in the work of many technical and social clubs to which he belonged. He was a trustee of Cooper Union, founded by his grandfather, and in 1915 was appointed a member of the United States Naval Consulting Board.

His chief inventions were the mercury-vapor electric lamp, the static converter or rectifier used to convert alternating currents into direct currents, the electrical interrupter, and the wireless receiver. The telephone relay and electric wave amplifier, as well as apparatus for use in connection with the wireless telephone and telegraph, were also devised by him.

## Major L. A. Fischer, Scientist, Dead

Major L. A. Fischer, chief of the Division of Weights and Measures of the U. S. Bureau of Standards, one of the most prominent scientists of Washington and the foremost leader of the movement to promote a uniform system of weights and measures, died on July 25 at his home in Washington, D. C.

L. A. Fischer

Major Fischer was born in Washington, D. C., on January 4, 1864. His activities in the field of weights and measures began early in life when he joined the staff of the old weights and measures office of the Coast and Geodetic Survey. After many years of active service in this office he took a prominent part in the establishment of its successor, the United States Bureau of Standards, in 1901, in which institution he was made chief of the Division of Weights and Measures. In addition his scientific attainments won him a world-wide reputation as one of the leading American metrologists.

For a number of years Major Fischer was regularly appointed by the President to serve on the Assay Commission. In the course of this work he personally tested the standards employed at the mint against carefully calibrated weights which were especially tested in his own laboratories at the Bureau. In 1915 he served as a member of the jury of awards at the Panama-Pacific Exposition. During the war he was commissioned major in the Ordnance Department of the United States Army and placed in immediate charge of the important section of gage design.

Major Fischer was a graduate of George Washington University. He was a member of the Washington Academy of Sciences, the American Physical Society, the Physical Society of France, a fellow of the American Association for the Advancement of Science, past-president of the Philosophical Society of Washington, secretary, since its organization, of the National Conference on Weights and Measures. He was also a member of the Cosmos Club of Washington.

Since his early youth he had been prominently identified with athletics in the District of Columbia. He was a leading oarsman in the Potomac and Analostan Boat Clubs and later became a member of the tennis teams of the Old Bachelor Tennis Club, the Dumbarton Club and the Columbia Country Club.

Major Fischer became a member of The American Society of Mechanical Engineers in 1918 and took most active interest in its work, particularly in the field of screw threads and limit gages. He was but recently elected chairman of the Washington Section of the Society.

## Kenneth Rushton Dies

Kenneth Rushton, vice-president in charge of engineering, The Baldwin Locomotive Works, died September 2, 1921, at the age of sixty years. Mr. Rushton was born in Philadelphia, Pa., and was educated in the city schools and Episcopal Academy. He served an apprenticeship as machinist under Hugo Bilgram, of Philadelphia, and afterward entered the employ of The Baldwin Locomotive Works in April 1881.

Mr. Rushton's association with The Baldwin Locomotive Works continued uninterruptedly until the time of his death; first as a draftsman, and later as designer, chief mechanical engineer, and finally as vice-president. He was the inventor of many appliances used in the construction of locomotives, and was closely associated with S. M. Vauclain in the development of the four-cylinder compound that bears the name of the latter. While Mr. Rushton did not travel extensively in the prosecution of his business, he represented Baldwin's abroad on some important missions. In 1913 he was sent to Chile, visiting various points of railroad interest on the west coast of South America, and in 1918 went to France in connection with the design of railway transport for artillery.

Kenneth Rushton

Mr. Rushton became a member of The American Society of Mechanical Engineers in 1918, and served actually on the Sub-Committee of its Boiler Code Committee on Boilers and Locomotives. He was also a member of the American Society for Testing Materials.

## Dean F. Paul Anderson, New Director of H. & V. E. Research Laboratory

F. Paul Anderson, dean of the College of Engineering, University of Kentucky, has been appointed director of the Research Laboratory of the Committee on Research of the American Society of Heating and Ventilating Engineers, to succeed the late John R. Allen. L. A. Scipio, who has been acting director since Dr. Allen's death in October 1920, has been recalled to his position as dean of Robert College, Constantinople.

Following his graduation from Purdue University in 1890, Dean Anderson spent some months as designer of special machinery with the Studebaker Company, at South Bend, after which he devoted a year to experimental engineering at Purdue University. For 30 years he has served respectively as professor of mechanical engineering, director of experimental laboratories, and dean of the College of Engineering of the University of Kentucky, formerly the State College of Kentucky. He was for 25 years engineer of tests for the Southern Railway Company, and at the same time carried on a consulting engineering and architectural business.

Dean Anderson has long been noted as an investigator, having been the first engineer in this country to experiment with Roentgen rays. At the University of Kentucky he specialized in steam and locomotive engineering and materially developed the laboratory.

Dean Anderson is a member of the Society for the Promotion of Engineering Education, The American Society of Mechanical Engineers, and the American Society of Heating and Ventilating Engineers, as well as of various other social and technical societies and clubs.

# News of The Federated American Engineering Societies

## Report of Patents Committee on Stanley Bill

The Patents Committee of American Engineering Council, of which Edwin J. Prindle is chairman, has recently issued a report on the Stanley Compulsory Working and License Patent Bill, S. 1838, which proposes to require that all alien-owned American patents shall be worked in this country within two years after granting. Some of the arguments for and against this bill were set forth in the July issue of Mechanical Engineering, page 494. The report of the American Engineering Council Committee states that the committee "believes that the changes proposed in the Stanley Bill would be much more harmful than beneficial and would probably ultimately be disastrous, and therefore recommends that the Stanley Bill be vigorously opposed." Some of the reasons which the committee report gives for this conclusion are, in part:

There is grave danger that if compulsory working, under penalty of having licenses granted to others, is introduced into our law, as applied to patents issued to foreigners, it will be extended to apply to all American patents. It would be a catastrophe to require that all American patents be worked within any limited period under penalty of losing the monopoly by having licenses granted thereunder by the Government.

Such a provision would strongly tend to impair the value of patents and would, to that extent, discourage or fail to induce the production of inventions. Such inventions as were produced would be largely those which could be monopolized by being kept secret.

The great prevalence of the inventive faculty in America is due to the stimulus of the promise of a monopoly for seventeen years which our patent law offers.

If the individual inventor, or even the corporation, were faced not only with the often back-breaking burden of expense in developing an invention, but also with the necessity of putting that invention on the market within two years, or even a much longer period, they would often not attempt what is now successfully put through.

An invention is often of no commercial value because it is ahead of its time, and the patent must wait until the art has grown up to it before it can be profitably worked. Under these circumstances, the expense of commercially working it would be entirely thrown away.

The making of a successful invention today is not usually a question of a single patent, but in the course of the development of the invention, to a thoroughly commercial form, a group of patents has usually been taken out, either upon the article itself or upon instrumentalities and processes for its manufacture, and the patents of others are often found to be infringed and need to be purchased. In such a case the patents would usually have been taken out successively over a number of years, and thus each patent of the series would, under the Stanley Bill, have to be worked within two years while the working of that patent alone was of no commercial value and the success of the enterprise as a whole was still in doubt and might never be achieved.

The requirements of the Stanley Bill would obviously discriminate strongly in favor of the wealthy, and against the poor, inventor. That would not only discourage the production of inventions, but harm industry in general, for there are many successful businesses in this country which are based upon the inventions of their owners made when they were without capital.

No country which has a compulsory working clause in its patent law produces anywhere near the number of inventions per capita or in importance which are produced in this country. The very small and seemingly insignificant inventions produced under our patent system are often of great value to the public, although usually not to their inventors, because they lead step by step to a point of view from which some one sees an opportunity to make a really important invention that would not otherwise have been produced.

## Registration of Engineers

A meeting of the American Engineering Council's Committee on Licensing and Registration of Engineers was held in the rooms of the Western Society of Engineers, Chicago, on September 19, for the purpose of giving a hearing on the Uniform Registration Law recommended by Engineering Council in November 1920. Engineers in general had previously been invited to prepare briefs and submit them to the Committee, either by mail before the meeting or in person at the hearing. The proposed changes were discussed in detail, as were also the recommendations on whether or not the Federation should use its influence to have the uniform law introduced in legislation in states where laws are not already in force. The findings of this hearing will be given in a later number of Mechanical Engineering.

## International Cost Conference

Mr. L. W. Wallace, secretary of the American Engineering Council conducted the third session of the International Cost Conference held under the auspices of the National Association of Cost Accountants, at Cleveland, September 14–16. Arrangements for this session were the result of the work on the part of the Committee on the Elimination of Waste in Industry. Three members of the Committee in addition to Mr. Wallace presented papers, namely, John H. Williams, William R. Basset, and Robert B. Wolf.

# Chemists Discuss Developments in Scientific Research

## American Chemical Society and Society of Chemical Industry Hold Four-Day International Meeting in New York City

THE sixty-second meeting of the American Chemical Society, held in New York September 7–10, was attended by over 6000 chemists representing that society, the American sections of the Society of Chemical Industry and the Société de Chimie Industrielle, the British Society of Chemical Industry and its Canadian sections, the American Electrochemical Society, and the American Institute of Chemical Engineers. The Chemists' Club was the social headquarters for this international gathering and the business sessions were held at Columbia University and the College of the City of New York.

Over a score of papers were presented. Arthur D. Little, chemical engineer and technologist of Boston, Mass., spoke on Energy: Its Source and Future Possibilities, discussing some of the new sources of energy. The radiant energy of the sun, he stated, "is only three small calories per minute per square centimeter of the earth's surface, but it has been calculated that a surface of only 10,000 square kilometers (3860 square miles) receives in a year, assuming only six hours as the effective day, a quantity of heat that corresponds to that produced by the burning of 3,650,000,000 tons of coal. The Desert of Sahara receives daily solar energy equivalent to that of 6,000,000,000 tons of coal. The world awaits the genius who will convert radiant energy into electric current." The energy of the earth's rotation and tidal energy were also discussed by Dr. Little. The former has thus far been utilized only through the gyroscope. Concerning the latter he believed that intermittent flow, varying head and other special conditions involved are likely to hold the development of tidal power within closely restricted limits. Kinetic energy possessed by radium and also by ordinary matter as the constitutional energy of atoms, he said, are further power sources of great interest to chemists.

Wilder D. Bancroft, professor of physical chemistry at Cornell University, presented a paper on Catalysis, the New Economic Factor. He was of the opinion that the most promising way in which chemists could develop methods of increasing production and decreasing costs lies in a better utilization of the possibilities of catalytic action. He predicted the use of a catalytic agent in speeding up the reaction which gives rise to cold light and in causing rain clouds to precipitate into arid regions and was sure that the availability of the energy in sunlight and in atoms involves catalysis. Reid of the Johns Hopkins University had apparently furnished the missing experimental proof. He passed a mixture of the vapors of ethyl aclohol and acetic acid for twenty-four hours over silica gel as catalytic agent, and during the whole of that time he obtained about 10 per cent more of ethyl acetate than corresponds to the theoretical equilibrium. The displacement of equilibrium by a catalytic agent he thinks may be an avenue to extraordinary possibilities in making organic compounds. A displacement of 10 per cent in the right direction in the synthesis of ammonia, for instance, would be revolutionary.

An interesting paper on a Chemically Controlled Automobile was presented by George G. Brown, Jr., an instructor in the chemical engineering department of the University of Michigan. Mr. Brown had been working for some time on the development of a carburetor which automatically delivers the leanest and most efficient mixture possible with every temperature condition when the car is running under light load, and automatically enriches the mixture according to decreased speed or increased load when the car encounters increased resistance, so that acceleration, hill climbing and flexibility are not sacrificed when obtaining maximum economy. This carburetor, he stated, produces a mileage of from 30 to 45 miles a gallon, depending on the car and the roads.

Dr. Sidney Born, of Muskogee, Okla., in speaking of saving petroleum at the wells, said that different processes were used at different fields. Among these processes are the steaming plant, the Cottrell or electrical, and the super-centrifuge. The latter method, by which petroleum is recovered from the emulsion of salt water, oil and various impurities found in many oil wells, makes possible an economy of millions of dollars.

Following a discussion of the German chemical industry by Francis P. Garvan, president of the Chemical Foundation, Inc., the meeting adopted a resolution to Congress, urging, among other things, the necessity of including in the permanent tariff bill a selective embargo for a limited period against importation of synthetic organic chemicals. Sir William Pope, professor of chemistry at Cambridge Univerity, touched on the same subject when in the course of his address on Mustard Gas he stated that every dollar which was spent in this country on German dyes during the war, and every pound spent in England for German dyes, was a contribution to the German war chest.

Dr. Leo H. Baekeland, honorary professor of chemical engineering in Columbia University, in his address on The Engineer: Human and Superior Director of Power, said that there are enormous possibilities in the range of photochemistry. "Our vast coal beds and our petroleum wells and our natural gas," he said, "are simply the results of light energy stored up from the plant or animal life of former geological periods, yet here is a field where the scientist or engineer has accomplished next to nothing."

Some of the other subjects discussed were Organization of Industrial Research in Canada, by Prof. R. F. Ruttan of the Canadian Chemical Society; Theories on the Development of Research, by Dr. Willis R. Whitney, head of the research department of the General Electric Company; Problem of Diffusion and Its Bearing on Civilization, by Prof. Ernst Cohen, professor of chemistry at the University of Utrecht; and Research Applied to the World's Work, by Dr. C. E. K. Mees, head of the research department of the Eastman Kodak Company.

The last day of the meeting was devoted to excursions to various industrial plants in New York, including those of the National Biscuit Company, the American Tobacco Company, Standard Oil Companies of New York and New Jersey, Manhattan Rubber Company, Passaic Print and Dye Works, and the Seaboard By-Product Coke Company.

It was decided to hold the 1922 convention in April at Birmingham, Ala., and the fall meeting at Pittsburgh in September.

## Book Notes

THE A.B.C. OF IRON AND STEEL. Edited by A. O. Backert. Penton Publishing Co., Cleveland, 1921. Cloth, 8 × 11 in., 408 pp., illus., $5.

This is a simple, concise, yet comprehensive account of the primary processes involved in the conversion of iron ore into finished products, intended for general readers who wish a knowledge of these processes, and for technical readers wishing general information on phases of the industry outside their own experience. The book is elaborately illustrated.

BROACHING PRACTICE. By E. K. Hammond. The Industrial Press, New York, 1921. Paper, 6 × 9 in., 122 pp., illus., $1.

For many years broaching has been used for cutting keyways and machining holes to a variety of shapes, but the method attracted little attention until comparatively recently. With the rise of the automibile industry, broaching machines came into common use and now are extensively used in building many products. This book is a concise review of modern practice, explaining the machines, the design of broaches and the application of the process to many classes of work.

CONCRETE DESIGNERS' MANUAL; TABLES AND DIAGRAMS FOR THE DESIGN OF REINFORCED CONCRETE STRUCTURES. By G. A. Hool and C. S. Whitney. McGraw-Hill Book Co., Inc., New York, 1921. Cloth, 276 pp., $4.

These tables and diagrams facilitate the rapid design of structures in accordance with the Joint Committee recommendations, the American Concrete Institute recommendations, the New York Building Code requirements and the Chicago Building Code requirements. Some of them are general enough also to be used when the requirements are different from those mentioned. The collection is the result of the authors' practical experience.

# CONTROL OF CORROSION IN IRON AND STEEL

(Continued from page 662)

are decidedly favorable, confirming the theory stated in the first part of this paper which has now been generally accepted, that corrosion is due primarily to the dissolved oxygen in water. The water is sprayed into a chamber under about 28in. vacuum, by which 90 per cent of the gases are removed and corrosion thereby reduced to one-quarter or one-fifth of the original amount.

It is much easier to study the various factors which influence corrosion in a closed system where all conditions are under better control. Early experiments in 1907 indicated the great influence of dissolved oxygen in water on corrosion. Careful laboratory experiments by Dr. W. H. Walker and the author, covering a period of several years have demonstrated that the amount of corrosion is almost directly proportional to the oxygen in solution, and also varies directly as the temperature. Hot-water heating systems in buildings invariably show no corrosion to speak of after 35 or 40 years' use, whereas frequently hot-water supply systems operating at the same average temperature with the same water last less than half of that time, the only difference being that the former carry no oxygen, while the water on entering the latter is usually saturated with oxygen.

### Protection Against Internal Corrosion

From the foregoing it will be seen that in addition to the use of protective coatings, under some conditions it is more economical to prevent internal corrosion by removing the dissolved oxygen from water. In fact, experience has shown that with hot water the latter method is much more effective and economical in the long run.

In practice the removal of oxygen from water has been accomplished in two ways:

1 By mechanical deaeration, for which there are two or three designs of apparatus in use giving satisfactory results.

2 By chemical combination with some material such as scrap sheet iron.

Both methods may be combined by using mechanical deaeration to remove the larger portion of oxygen and the chemical treatment for residual oxygen. Considerable has been written on this subject during the last few years with reference to the control of corrosion in hot-water supply systems, to which those interested may refer.[1] The most economical plan for any particular case depends very largely on local conditions.

The control of corrosion in condensers, especially where salt water is used, may be accomplished by deaeration, and there are probably many other cases where this principle can be applied economically to engineering practice.

For the internal protection of water mains by coating the metal, under most conditions a dip in a bath of well-refined asphalt or coal tar will be sufficient. Again the importance of thorough cleaning and the removal of all scale from the steel, so far as practicable, should be emphasized.

Concrete has been used to a limited extent for the protection of the inside of pipes from 1 in. to 11 ft. in diameter. Small service pipes have been used for thirty years in New England with an internal coating of $^1/_8$ in. of neat cement applied by means of some simple appliances designed for the purpose. This coating has also shown great durability as a lining for steel or wrought-iron pipe carrying mine water, and when properly applied to the clean surface and about $^3/_4$ in. in thickness, is difficult to break off or injure unless there is much variation in temperature.

The 11-ft.-diameter rivited-steel pipe sections of the Catskill Aqueduct were lined with 2 in. of portland-cement grout. The plates of which this pipe was made were first pickled free from scale and given a coat of whitewash to prevent rusting. The outside of the pipe was protected by a coat of 1:3:5 concrete mixture 4 in. thick at the top. The reports from this line, which was put into service in 1915, indicate that this coating has been satisfactory so far as can be ascertained at present. It is interesting to find that the friction losses in the cement-lined Catskill conduits are less than in the unlined pipe under these conditions, notwithstanding the reduction in diameter of the lined pipe.

What has been written above necessarily deals in general principles. The details of the application of these principles to practice in various cases will of course require variation to suit local conditions. Considering the great economical importance of conservation of material in our day, it would seem that the boundaries of engineering practice should be broadened out a little so as to include more of anti-corrosion engineering.

[1] Paper by J. R. McDermet on the Separation of Dissolved Gases from Water and discussion. A.S.M.E. meeting, St. Louis, May 1920. Papers by F. N Speller, W. H. Walker and R. G. Knowland, Trans. A.S.H.&V. Engrs., 1918 and 1920.

## What of the Young Engineer?

(Continued from page 691)

or so? Have the bigger men in our profession deliberated upon the question and decided that no help need be given to the new men to find themselves? Again, are over a thousand trained young men to be cast aside as surplus junk? Can the interval be bridged without their help, and without loss to the engineering world? This is hardly conceivable; but if it is so, then why not sound the warning to the colleges to cut down on their engineering personnel? Let these men be guided into less crowded channels to be trained in other lines.

However, it does not seem probable that such is the case. Perhaps conditions are still so abnormal as to aggravate a usually healthy state of affairs. At the same time the problem is here and is a very serious one, not only from the remunerative standpoint, but also in its effect upon the morale of our young men. It is upon the shoulders of this type of young men that the burden rests of keeping a state of healthy normalcy in our country. Education is the best combative measure against bolshevism and anarchism. Any condition of affairs tending to break the spirit of these young men, to reduce them to a state of hopelessness and lethargy, will have its immediate effect upon their attitude toward such matters. They will not champion a state of affairs which they believe in their hearts to be unfair.

Engineers have in the past advocated a far-sighted policy. They have prepared for the future as well as the present. In this work they have been the pioneers, watching our resources, husbanding our reserves, and sounding the warning of waste and inefficiency. Can it be that they are now being overtaken by a wave of materialism; that they are no longer for what may affect the future as long as they make the most material gain in the present? These methods have been consistently condemned by engineers for many years. It is hard to believe they are coming to the same sort of policy against which they have so long fought. Yet why not prepare for the future in man reserve as well as machine and money reserve?

This is the question that is running through the mind of the graduate of today. What is your answer, Mr. Senior Engineer?

New York, N. Y. W. CULLIN.

## 1921 Condensed Catalogues Being Distributed

The eleventh annual (1921) volume of Condensed Catalogues of Mechanical Equipment is now being distributed to the membership. This edition contains more than a hundred pages of catalogue data not included in the 1920 volume, important changes in the pages continued from last year, and a more comprehensive Directory Section, thoroughly revised and brought up to date with respect to the changes that have taken place during the past year.

There are 648 catalogue pages containing the condensed data of 495 firms. The arrangement of this data is uniform and convenient and includes descriptions of over 1300 pieces of apparatus, instruments, materials and the like—illustrated by over 1700 engravings. The indexing and classifying is thoroughly done so that the particular data sought can be instantly found.

The Mechanical Equipment Directory (green pages) contains the names and addresses of over 4000 firms under 3000 classifications of equipment. The names and addresses of over 700 consulting engineers in the Consulting Engineers Directory (yellow pages) appear under 400 classifications.

The volume may be purchased by non-members at $4.00 a copy plus 25 cents carrying charges. Extra copies for members may be had for $3.25.

# THE ENGINEERING INDEX

*(Registered U. S. Patent Office and Canadian Patent Office.)*

*THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.*

*Photostatic copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents per page, plus postage. A separate print is required for each page of the larger periodicals, but wherever possible two small or medium-sized pages will be photographed together on the same print. The bill will be mailed with the print. When ordering photostats identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.*

**ABRASIVE WHEELS**

**Phantom.** Grinding with a Phantom Wheel. Ellsworth Sheldon. Am. Mach., vol. 55, no. 2, July 14, 1921, pp. 44–45, 5 figs. Difficulty of grinding thin work without heating. Wheel set at angle eliminates much of the pressure.

**AERODYNAMICS**

**Testing Station.** The Aerodynamic Experimental Station at Göttingen. Engineering, vol. 112, no. 2901, Aug. 5, 1921, pp. 218–220, 11 figs. Construction details of new experimental station. Translated from report entitled "Ergebnisse der Aerodynamischen Versuchsanstalt zu Göttingen," published by A. Oldenbourg, Munich and Berlin.

**AEROPLANE ENGINES**

**Clearance Volumes.** An Instrument for Measuring Clearance Volumes, H. C. Dickinson. A.S.R.E. Jl., vol. 7, no. 6, May 1921, pp. 460–463, 4 figs. Discusses aircraft-engine cylinders.

**Fiat.** 300 HP. Fiat Model A-12 Engine. Aerial Age, vol. 13, no. 18, July 11, 1921, pp. 415–416, 4 figs. Aviation engine said to resemble Mercedes 260-hp. engine. It has six vertical water-cooled cylinders and operates with gasoline as a fuel on four-stroke cycle.

**AEROPLANE PROPELLERS**

**Theory.** General Theory of Aeroplane Propellers (Théorie Générale de l'Hélice Propulsive), A. Rateau, M. R. Soreau and M. S. Drzewiecki. L'Aerophile vol. 29, nos. 9–10, May 1–15, 1921, pp. 139–146, 7 figs. Development of formulas and comparison with experimental results.

**AEROPLANES**

**All-Metal.** German Metal Airplanes (L'avion metallique en Allemagne), Roger Couturier. L'Aéronautique, vol. 3, no. 25, June 1921, pp. 249–254, 11 figs. Describes the Zeppelin-Staaken, Zeppelin-Dornier, also Dornier hydroplanes. (Concluded.)

**Ansaldo Commerical Biplane.** The Ansaldo A-300 C Commercial Biplane. Flight, vol. 13, no. 26, June 30, 1921, pp. 437–438. Specifications: Span, 44 ft. 9 1/2 in.; chord, 6 ft. 6 in.; overall length, 31 ft. 8 in.; overall height, 10 ft. 9 1/2 in.; total weight, 4187 lb.; useful load, 1653 lb.; speed range, 43–120 m.p.h.; climb (15 min.), 7000 ft.

**Balancing.** Aeroplane Balance. L. Huguet. Aerial Age, vol. 13, no. 18, July 11, 1921, pp. 417–419. 1 fig. Influence of wing profile and of passive resistance; influence of steering mechanism; sensitiveness of aeroplane to action of steering mechanism; equilibrium of forces. (Concluded.) Translated from "La Vie Technique & Industrielle."

**Bristol Commercial.** The Bristol Commercial Ten-Seater Biplane. Flight, vol. 13, no. 27, July 7, 1921, pp. 457–458, 3 figs. Characteristics: Span, 54 ft.; length overall, 42 ft.; height, 11 ft.; total weight as passenger machine, 6801 lb.; as cargo machine, 7100 lb.; speed at ground level full load, 122 m.p.h.; etc.

**Farman.** Farman Improved Aeroplane. Commonwealth Engr., vol. 8, no. 10, May 1, 1921, pp. 301–302, 1 fig. Specifications: Span, 23 ft. 4 in.; length, 20 ft. 11 in.; height 8 ft. 2 1/2 in.; load-carrying capacity including pilot and passenger, 440 lb., equal to its own weight; engine, 60 hp.; max. speed 87 mi. per hr.; climb, 5000 ft. in 8 mm. 35 sec.

**Fiat.** Fiat 10 Passenger Airplane. Aviation, vol. 11, no. 5, August 1, 1921, pp. 139, 1 fig. Gives particulars of design and dimensions. Maximum speed 125 m.p.h.

**Flotation Gear.** DH-4 Emergency Flotation Gear. Aviation, vol. 11, no. 4, July 25, 1921, p. 103, 2 figs. Describes emergency flotation gear developed by Engineering Division of Army Air Service, consisting of a pair of collapsible fuselage air bags, front and rear hydro-surfaces, wing floats, wheel-releasing mechanism and an air system for inflation of flotation bags.

**Fokker.** The Commercial Monoplane "Fokker F.-III" (Le Monoplan Commercial "Fokker F-III"), Roger Couturier. L'Aéronautique, vol. 3, no. 26, July 1921 pp. 286–288, 2 figs. Made by Nederlandsche Vliegtuigenfabrik at Amsterdam. Description and comparative data.

**Horsepower Chart.** Aeroplane Flight Endurance—I. Aerial Age Weekly, vol. 13, no. 21, August 1, 1921, pp. 490–491, 1 fig. Describes a chart for determining minimum horsepower required or maximum horsepower available at any altitude possible for the aeroplane to reach.

**Lift and Drag Coefficients.** The Variation of Aerofoil Lift and Drag Coefficients with Changes in Size and Speed, Walter S. Diehl. Natl. Advisory Committee Aeronautics, Report No. 111, 10 pp., 8 figs. Results of investigation of existing scale-correction data and derivation of an original method for making these corrections rapidly and accurately.

**Remington-Burnelli.** The Remington-Burnelli Airliner. Aerial Age, vol. 13, no. 18, July 11, 1921, pp. 420–421 and 416, 3 figs. Specifications: Length overall, 41 ft. 2 in.; height, 18 ft.; span, 74 ft.; chord, 10 ft. 6 in.; horse power, 1000; climb, 900 ft. per min.; max. speed, 110 m.p.h.; etc.

**Sablatnig P.3.** The Sablatnig P.3 Monoplane. Flight, vol. 13, no. 31, August 4, 1921, pp. 521–525, 15 figs. Germany's first commercial aeroplane.

**Saulnier Three-Engined Monoplane.** The Saulnier Three-Engines Monoplane. Aviation, vol. 11, no. 3, July 18, 1921, pp. 71–72, 2 figs. Characteristics: Span, 93 ft.; length overall, 56 ft. 8 in.; height, 10 ft. 5 in.; max. chord, 19 ft. 1/4 in.; wing area, 1300 sq. ft.; engines, 3500 hp. Liberty; weight loaded, 15,500 lb.; high speed, 150 m.p.h.; ceiling, 15,000 ft.

**Spad.** The Spad "Berline" S.33. Aerial Age Weekly, vol. 13, no. 21, August 1, 1921, pp. 488–489, 3 figs. The fuselage is of the monocoque streamline type, the wings having a backswept top plane. Performance data.

**Truss Ribs.** Experimental Reinforced Plywood Truss Ribs. Aerial Age Weekly, vol. 13, no. 23, August 15, 1921, pp. 539–541, 10 figs. Compares plywood truss ribs with other types and draws conclusions based on tests. (To be continued.)

**Wing Beams.** Merits of Different Splices for Airplane Wing Beams. Jl. Soc. Automotive Engrs., vol. 9, no. 2, August 1921, pp. 133–138, 1 fig. Discusses the construction of the beam, also discusses scarf and splices and gives results of experiments.

**Wing-Load Indicator.** The Klemperer Wing-Load Indicator, Leon N. W. Colin. Aviation, vol. 11, no. 6, August 8, 1921, pp. 164–165, 1 fig. Description of operation and advantages.

[See also HYDROPLANES; PARACHUTES; SEAPLANES.]

**AIR**

**Dust Content.** Comparative Tests of Air Dustiness With the Dust Counter, Konimeter and Sugar Tube, S. H. Katz & L. J. Trostel. Jl. Am. Soc. Heat. & Vent. Engrs., vol 27, no. 5, July 1921, pp. 519–527 and (discussion) pp. 527–528, 8 figs. Particulars of comparative tests of air dustiness with dust counter, konimeter and sugar tube in granite-working plants.

**AIRCRAFT CONSTRUCTION MATERIALS**

**Fabrics.** Airship Fabrics, J. W. W. Dyer. Aeronautical Jl., vol. 25, no. 127, July 1921, pp. 332–348 and (discussion) pp. 349–356. Deals briefly with different types of fabrics, classified according to main functions of each, and describes their structure and behavior and chief factors affecting their permanence when in service.

**AIRSHIPS**

**Masts.** Airship Mast at Aerial Terminal in Pulham, Eng. (Le Mat d'Amarrage Pour Dirigeable de la Gare Aérienne de Pulham, Angleterre). Le Génie Civil, vol. 78, no. 24, June 11, 1921, pp. 493–496, 6 figs. Nose of airship is fastened to mechanism at top of mast. Mechanism is capable of rotating as airship is moved by wind.

**Rigid.** Rigid Airships, J. L. Bartlett. Aeronautical Jl., vol. 25, no. 127, July 1921, pp. 357–377, 8 figs. Two lectures, first dealing with general aerostatical principles governing flight of lighter-than-air craft, and describing various types of airships, with special reference to rigid airships; second referring to some important problems in design of rigid airship. Appendices.

**ALIGNMENT CHARTS**

**Advantages.** Note on Some Useful Alignment Charts, J. A. P. Gibb. Bul. Instn. Min. & Metallurgy, no. 200, May 1921, pp. 1–11, 6 figs. on supp. plates. Notes and chart presented with object of drawing attention to advantages which alignment charts offer as compared with the more commonly used intercept and correlation charts.

**Uses.** Alignment Charts—XIV, Arnold A. Arnold. Mech. World, vol. 70, no. 1880, July 1, 1921, pp. 9–10, 1 fig. Practical example: marine-engine shafts and crankshafts. Principal proportions of chart. Connection between charts. (Concluded.)

**ALLOYS**

See ALUMINUM ALLOYS; BEARING METALS; MONEL METAL.

**ALUMINUM**

**Exposition, Paris.** Exposition of New Industrial Application of Aluminum, Magnesium, Calcium and Sodium at the Société d'Encouragement, Paris (L'Exposition des Nouvellse Applications Industrielles de l'Aluminium, du Magnésium, du Calcium et de Sodium, à la Société d'Encouragement pour l'Industrie Nationale). Le Génie Civil, vol. 79, no. 2, July 9, 1921, pp. 36–39. Particulars of program of exposition and reports of four lectures on aluminum and its alloys.

**Properties and Uses.** Aluminum, Magnesium, Calcium and Sodium (L'aluminium, le magnésium, le calcium et le sodium). Revue Générale de l'Eléctricité, vol. 10, no. 1, July 2, 1921, pp. 21–29. Report of eight lectures given at the recent expo-



**NOTE.—The abbreviations used in indexing are as follows:**
**Academy (Acad.)**
**American (Am.)**
**Associated (Assoc.)**
**Association (Assn.)**
**Bulletin (Bul.)**
**Bureau (Bur.)**
**Canadian (Can.)**
**Chemical or Chemistry (Chem.)**
**Electrical or Electric (Elec.)**
**Electrician (Elecn.)**
**Engineer[s] (Engr.[s])**
**Engineering (Eng.)**
**Gazette (Gaz.)**
**General (Gen.)**
**Geological (Geol.)**
**Heating (Heat.)**
**Industrial (Indus.)**
**Institute (Inst.)**
**Institution (Instn.)**
**International (Int.)**
**Journal (Jl.)**
**London (Lond.)**
**Machinery (Machy.)**
**Machinist (Mach.)**
**Magazine (Mag.)**
**Marine (Mar.)**
**Materials (Matls.)**
**Mechanical (Mech.)**
**Metallurgical (Met.)**
**Mining (Min.)**
**Municipal (Mun.)**
**National (Nat.)**
**New England (N. E.)**
**Proceedings (Proc.)**
**Record (Rec.)**
**Refrigerating (Refrig.)**
**Review (Rev.)**
**Railway (Ry.)**
**Scientific or Science (Sci.)**
**Society (Soc.)**
**State names (Ill., Minn., etc.)**
**Supplement (Supp.)**
**Transactions (Trans.)**
**United States (U. S.)**
**Ventilating (Vent.)**
**Western (West.)**

sition, on the properties and uses of these metals and their alloys.

**ALUMINUM ALLOYS**

**Melting.** Constitution of Gas Atmospheres in Aluminum-Alloy Melting Furnaces, Robert J. Anderson and J. H. Capps. Chem. & Metallurgical Eng., vol. 25, no. 2, July 13, 1921, pp. 54-60, 7 figs. Tabulated analyses of atmospheres of various types of aluminum furnaces, sampled at short intervals during operation, furnishing data necessary for study of dross and metal losses due to furnace operation.

Iron-Pot Melting Practice for Aluminium Alloys, Robert J. Anderson. Metal Industry (Lond.), vol. 19, nos. 1 and 4, July 1 and 22, 1921, pp. 8-9 and 65-66. Present-day methods and detailed investigation of them in practice. See also Metal Industry (New York), vol. 19, no. 7, July 1921, pp. 285-287, 4 figs.

**Uses.** Aluminium and Its Alloys in Engineering, John G. A. Rhodin. Engineer, vol. 131, no. 3417, June 24, 1921, pp. 659-660. Blowing and cracking of castings is attributed to overheating.

**AMMONIA**

**Coke-Oven Gas as Source.** Increasing the Ammonia Yield with the Distillation of Anthracite (Beiträge zur Erhöhung der Ammoniakausbeute bei der Destillation der Steinkohle), Friedrich Sommer. Stahl u. Eisen, vol. 41, no. 25, June 23, 1921, pp. 852-859, 5 figs. Process for recovery of hydrocyanic acid contained in coke-oven gas through conversion into ammonium sulphate.

**Total Heat Diagrams.** Total Heat Diagrams For Ammonia, E. F. Mueller and C. H. Meyers. A.S.R. E. Jl., vol. 7 no. 6, May 1921, pp. 419-425, 6 figs. Discusses the advantages of using total heat-entropy diagrams of which examples are given in rectangular and oblique coördinates, also total heat-pressure diagrams.

**AMMUNITION**

**Colloided Smokeless Powder.** Absorption of Moisture by Colloided Smokeless Powder, Tenney L. Davis. Army Ordnance, vol. 2, no. 1, July-August 1921, pp. 9-12, 2 figs. Discusses means of determining the hygroscopicity of the solvent-free material colloid and for comparing the hygroscopicity of various kinds of powder.

**ARTILLERY**

**Post-War Matériel.** Post-War Artillery Matériel G. F. Jenks. Army Ordnance, vol. 2, no. 1, July-August 1921, pp. 1-8, 13 figs. Discusses improvements due to the war and pending. Considers gun carriages and anti-aircraft matérial, motor matérial, etc.

**ASH HANDLING**

**Plants.** Ash-Handling Plant at Poplar Electric Power Station. Engineering, vol. 112, no. 2901, Aug. 5, 1921, pp. 231-233, 24 figs. Construction and operation of plant constructed by Underfeed Stoker Co., Ltd., London.

**AUTOGENOUS WELDING**

**Boiler Repairs.** Speeding Up Boiler Repairs by Use of Autogenous Welding Processes, C. E. Lester. Boiler Maker, vol. 21, no. 7, July 1921, pp. 194-195. Details of welding operations used in repairing flue sheets.

**AUTOMOBILE ENGINES**

**Fuel Economy.** Effect on Fuel Economy of Refinements in Engine Design, L. Mantell. Automotive Ind., vol. 45, no. 4, July 28, 1921, pp. 161-167, 9 figs. Discusses factors of design which affect performance and economy, such as pulsating flow, valve timing, scavenging, etc.

**Localized Charge and Supercharging.** Experiments with Localized Charge and Supercharging Engines, Harry R. Ricardo. Automotive Industries, vol. 45, no. 2, July 14, 1921, pp. 61-68, 18 figs. Report of investigations demonstrating how mean effective pressure and economy can both be increased by use of stratified charge. Excess air and cooled exhaust gas are employed as diluents to limit maximum temperature of cycle and prevent detonation. Unusually high fuel economy at part load is obtained by use of nonthrottling engine. (Abstract.) Paper presented before (British) Instn. Automobile Engrs.

**AUTOMOBILE FUELS**

**Efficient Utilization.** More Miles Per Gallon, O. C. Berry. Chem. & Metallurgical Eng., vol. 25, no. 2, July 13, 1921, pp. 64-68, 4 figs. Discussion on carburetion as affecting motor efficiency, brake horsepower and work. Spark timing and brake load. Relation between torque and engine speed. Possibilities of more efficient utilization of motor fuels. Paper read at Automotive Symposium, Am. Inst. Chem. Engrs.

[See also GASOLINE.]

**AUTOMOBILES**

**Assembly System.** Economy and Efficiency Increased by New Final Assembly System, Norman G. Shidle. Automotive Industries, vol. 45, no. 2, July 14, 1921, pp. 69-72, 8 figs. Describes new final assembly system and discusses methods of equipment.

**Benz Chassis.** One Four and One Six-Cylinder Chassis Comprise Benz Line, Benno R. Dierfeld. Automotive Industries, vol. 45, no. 2, July 14, 1921, pp. 56-60, 15 figs. Aside from engine, chassis are said to be practically identical and possess but few novel features. Transmission brake has provision for water cooling. Steering gear has unhardened screw with non-adjustable babbitt-lined nut.

**Berliet.** The 16-20 Hp. Berliet, Model VI, 1921. Auto, vol. 26, no. 27, July 7, 1921, pp. 580-583, 6 figs. Notable features are said to be the pressed steel bridge-type live axle; light but well-base torque-tube; well-extended rear suspension; adoption of dynamotor unit for lighting and starting; and grouping of all connections to concentric brakes.

**Buick.** New Buick Four Similar to Six of Same Make, J. Edward Schipper. Automotive Ind., vol. 45, no. 6, August 11, 1921, pp. 255-258, 6 figs. Description of design and equipment.

**European vs. American Practice.** Comparison of European and American Automobile Practice. Jl. Soc. Automotive Engrs., vol. 9, no. 2, August 1921, pp. 109-115 and Discussion 115-117. Comparison of general design, road conditions, etc.

**Humber.** The 15.9 Hp. Humber Chassis. Automobile Engr., vol. 11, no. 152, July 1921, pp. 234-241, 15 figs. Revised model of the 14-hp. design. A four-cylinder L-headed engine is employed with 80-mm. bore and 140-mm. stroke.

**Kerosene Vaporizers.** A Paraffin Vaporizer. Automobile Engr., vol. 11, no. 152, July 1921, pp. 252-253, 4 figs. New system for utilizing heavy fuel on commercial vehicles.

**Leach.** Far Western Custom Built Car Has Many Features. Automotive Mfr., vol. 43, no. 3, June 1921, pp. 7-10, 7 figs. Describes the Leach Six built by Leach Biltwell Motor Co., Los Angeles. Motor is specially built 6-cylinder unit of 3½-in. bore and 5¼-in. stroke, and 60 hp. at 2000 r.p.m.; weight, 3800 lb.

**Locking Devices.** Automobile Locking-Device Classification and Theft Insurance. Jl. Soc. Automotive Engrs., vol. 9, no. 2, August 1921, pp. 95-100 and Discussion pp. 100-106. Considers design factor in insurance and fire hazard.

**Moller.** Moller a New American Light Car. Motor Age, vol. 40, no. 2, July 14, 1921, pp. 18-19, 4 figs. Car designed along European lines weighs 850 lb.; chassis has 100-in. wheelbase and 50-in. tread.

**Rolls-Royce.** Some Unusual Features of the Rolls-Royce Car, Fred H. Colvin. Am. Mach., vol. 55, no. 3, July 21, 1921, pp. 85-86, 7 figs. Power transmitted through large ball joint. Bracing used at rear end of chassis. Axle and torque tubes made of steel forgings.

**Star.** The 11.9 Hp. Star. Auto, vol. 26, no. 28 July 14, 1921, pp. 600-602, 4 figs. Engine is monobloc with four cylinders 69 mm. by 120 mm. bore and stroke respectively; wheelbase is 9 ft. and track 4 ft.; wheels are 30 in. fitted with 3½-in. tires.

**Transmission Cases.** Machining and Inspecting Transmission Cases, Fred H. Colvin. Am. Mach., vol. 55, no. 4, July 28, 1921, pp. 143-147, 23 figs. Fixtures hold aluminum cases without springing. Drilling and tapping operations. Inspection gages that insure accurate alignment.

**Transmission Gear.** Machining the Wrigley Automobile Transmission Gear I and II, I. W. Chubb. Am. Mach., vol. 55, nos. 5 and 7, Aug. 4 and 18, 1921, pp. 176-178 and 252-255, 17 figs. Aug. 4: Modern production methods in English plant. Forms necessary for accurate record keeping. Aug. 18: Using mechanical conveyors to eliminate handling progressive machining of automobile parts. Inspection tools and methods for rough and finished parts.

**Voiturette.** The 10 Hp. B.A.C. Auto-Motor Jl. vol. 26, no. 31, August 4, 1921, pp. 665-668, 7 figs. Description of a voiturette made by the British Automotive Company.

**AVIATION**

**Aerial Transportion.** Value of Airplanes in Transportation (De la Valeur de l'Avion Comme Engin de Transport), L. Hirschauer. L'Aeronautique, vol. 3, no. 25, June 1921, pp. 255-258, 2 figs. Discusses security, regularity, speed, stops, etc. (To be continued.)

**Commercial.** Commercial Aviation in Germany, Erik Hildesheim. Aviation, vol. 11, no. 5, August 1, 1921, pp. 135-136, 1 fig. Considers conditions of subsidy, planes under construction, air transport service and passenger rates.

**Luminous Beacons.** Luminous Beacons on Aerial Routes For Nocturnal Flying (Le balisage lumineux des routes aeriennes pour la navigation nocturne). Le Genie Civil, vol. 79, no. 5, July 30, 1921, pp. 111-112, 2 figs. (From l'Aerophile.) Discusses lighthouses with fixed and intermittent light signals.

**AXLES**

**Machining Methods.** Machining Front Axles. Eng. Production, vol. 3, no. 40, July 7, 1921, pp. 4-6, 7 figs. Methods employed for intensive production.

# B

**BEAMS**

**Reinforced-Concrete.** Reinforced-concrete Beams —II, T. C. Broom. Mech. Wld., vol. 70, no. 1803, July 22, 1921, pp. 68-69. Discusses rectangular concrete beam with double reinforcement. (To be continued.)

Strength of the Reinforced Thin-plate Beam, Held at Its Ends, and Subject to a Uniformly Distributed Load—Special Case, B. C. Laws. London, Edenburgh and Dublin. Phil. Mag. & Jl. of Sci., vol. 42, no. 248, 6th series, August 1921, pp. 281-287, 3 figs. Continuation of a mathematical investigation started in a previous paper.

**BEARING METALS**

**Properties at High Temperatures.** Properties of White Metal Bearing Alloys At Elevated Temperatures, John R. Freeman Jr. and R. W. Woodward. Raw Material, vol. 4, no. 7, July 1921, pp. 241-245, 7 figs. Describes tests carried out by the Bureau of Standards on five alloys.

**BEARINGS, BALL**

**Manufacture.** A Modern Ball Bearing Works. Eng. Prod., vol. 3, no. 44, August 4, 1921, pp. 108-115, 24 figs. Production methods on accurate repetition work. Description of works of Rudge-Whitworth, Ltd., Sparkhill, Birmingham.

**BELTING**

**Balata.** Balata and Fabric Belt Formulas and Chart, W. F. Schaphorst. Power Plant Eng., vol. 25, no. 15, August 1, 1921, pp. 769-770.

**Rubber.** Revised Rubber Belt Specifications Adopted by A.S.T.M. Belting, vol. 19, no. 1, July 1921, pp. 13-14, 1 fig. Principal changes provide for increase in allowable stretch from 5 to 6 per cent and reduction of ultimate strength from 285 to 260 lb. Revised specification submitted by Am. Soc. Testing Materials.

**BLAST FURNACES**

**Electric.** The Metallurgy of Electric Blast Furnaces (Ueber die Metallurgie des Elektrohochofens), R. Durrer. Stahl u. Eisen, vol. 41, no. 22, June 2, 1921, pp. 753-757, 1 fig. Discussion of certain metallurgical phenomena in electric blast furnaces with special regard to work of Bo Kalling (see Jernkontorets Annaler, 1919, pp. 413-430) dealing with hot and cold working; part played by direct and indirect reduction in total reduction.

**BOILER EXPLOSIONS**

**Causes.** Boiler Explosion at a London Hospital. Engineering, vol. 112, no. 2899, July 22, 1921, pp. 148-149. Report issued by Board of Trade states that explosion was primarily due to generation of excessive pressure in boiler consequent upon fire being lit in boiler with all outlets closed and relief valve inoperative.

**BOILER FEEDWATER**

**Treatment.** Power Plant Management—I, Robert June. Refrigerating World, vol. 56, no. 7, July 1921, pp. 21-23. Notes on boiler-water treatment. Specifications for ideal water-purification plant.

**BOILER PLANTS**

**Modernizing.** Modernizing a Cotton Mill Boiler Plant, Charles T. Main. Textile World, vol. 60, no. 6, August 6, 1921, pp. 87-89, 4 figs. Change from hand firing to stoker firing.

**BOILER TUBES**

**Charcoal Iron.** The Manufacture of Charcoal Iron Boiler Tubes. Boiler Maker, vol. 21, no. 7, July 1921, pp. 187-190 and 212, 9 figs. Methods and machines employed by Parkesburg Iron Co.

**BOILERS**

**Accessories.** Boiler Accessories from a Safety View Point. Power House, vol. 14, no. 14, July 20, 1921, pp. 28-31. Discusses various mountings of the modern boiler and makes suggestions for greater safety.

**Code Rulings, Pennsylvania.** Boiler Code Rulings of Pennsylvania Board. Boiler Maker, vol. 21, no. 7, July 1921, pp. 196-197. Use of autogenous welding in boilers outlined. Inspection and standard stamping of boilers. Rulings adopted May 24, 1921, by Industrial Board, Dept. of Labor and Industry, Pa.

**Combustion and Efficiency.** Theory of Combustion and Efficiency of Steam Boilers, Arthur R. Norris. Practical Engr., vol. 63, no. 1792, June 30, 1921, pp. 412-413. Gives empirical formula for calculation of calorific value of any fuel when chemical composition is known. Calculation of loss of heat in boilers.

**Inspection.** Inspecting the Boiler, W. M. McNeill. Power Plant Eng., vol. 25, no. 15, Aug. 1, 1921, pp. 752-753. What to look for and where to look for it.

**Losses.** Minimizing Steam Boiler Losses—III, Robert June. Gas Age, vol. 48, no. 1, July 11, 1921, pp. 7-9. Notes on steam-power management.

**BOMBING**

**Aeroplane.** Airplane Bombing, E. J. Loring. Army Ordnance, vol. 2, no. 1, July-August 1921, pp. 21-22, 3 figs. Discusses trajectory and accuracy of aim.

**BRAKES**

**Hand.** Efficient Hand Brakes for Freight Cars, Frank N. Grigg. Southern and Southwestern Ry. Club, vol. 16, no. 3, May 19, 1921, pp. 10-34, 5 figs. General description, causes of accidents, up-keep.

**BRASS**

**High-Resistance.** High-Resistance Brass, Pendleton Powell. Metal Ind., (Lond.), vol. 19, no. 4, July 22, 1921, pp. 62-64. Discusses molding, melting, pouring, use of scrap, etc.

**Season Cracking.** The Season-Cracking of Brass and Other Copper Alloys, H. Moore. Engineering, vol. 112, no. 2902, Aug. 12, 1921, pp. 262-264, 9 figs. Results of investigation of season cracking carried during period of some years by Research Department, Woolwich, England. (Abstract.) Paper read before Inst. Metals. (To be continued.)

**BRONZE**

**Manganese.** Methods of Casting Manganese-Bronze Test Bars as a Check on Melts of Small Castings, E. H. Dix, Jr. Metal Ind., vol. 19, no. 8, August 1921, pp. 315-317, 2 figs. Results of experiments made to fix upon a satisfactory method.

**BUILDING CONSTRUCTION**

**Bush Buildings, London.** Construction Features in the Bush Buildings, London. Am. Architect, vol. 120, no. 2372, July 20, 1921, pp. 53-60, 12 figs. 30,000 cu. yd. of earth were excavated for foundations and basement. Details of sidewalk vaults, walls and footings, steel framing, etc.

**BUILDINGS**

**Acoustics.** Acoustical Properties of Buildings, F. R. Watson. Jl. Western Soc. Engrs., vol. 26, no. 7, July 1921, pp. 241-247, 3 figs. It is shown that one important problem in acoustics of buildings lies in sound proofing of various rooms.

**Office.** Fire Resistive Construction of Office Buildings, Fire & Water Eng., vol. 70, no. 4, July 27, 1921, pp. 154-155, 163 and 169. Report of Nat. Fire Prot. Assoc. Committee on building construction.

**Steel-Frame.** Reducing the Cost of Steel-Frame Buildings, R. Fleming. Eng. & Contracting, vol. 56, no. 4, July 27, 1921, pp. 83-86. Considers the questions of design, specifications and standardization in this connection.

# C

**CABLES**

**Aerial.** Suspension Cables and Their Use in Construction (Les Cables de Suspension et leur emploi dans la construction). Le Génie Civil, vol. 79, no. 3, July 16, 1921, pp. 59-63, 11 figs. Describes the manufacture of cables and gives illustrations of their application.

**CABLEWAYS**

**French.** The Cableway in Hohneck (Alsace) (Die Drahtseilbahn am Hohneck). Fördertechnik u. Frachtverkehr, vol. 14, no. 6, Mar. 18, 1921, pp. 71-72. Describes cableway of the French army for transportation of supplies to the front line.

**CALORIMETERS**

**Coal.** The Calorimetry of Solid Fuel—III. Eng. & Ind. Management, vol. 6, no. 3, July 21, 1921, pp. 62-64, 3 figs. Deals with the Wm. Thompson, Rosenhain and Darling calorimeter.

**Fairweather Gas-Testing.** The "Fairweather" Recording Calorimeter. Gas Jl., vol. 154, no. 3031, June 15, 1921, pp. 628-629, 2 figs. Results of tests with described instrument show that it gives a continuous record within 1/2 per cent of accuracy.

**Simmance Recording.** Fifth Report of the Research Sub-Committee on the Gas Investigation Committee of the Institution of Gas Engineers. Gas Jl., vol. 154, nos. 3032, 3033, June 22 and 29, 1921, pp. 677-684 and 744-750 and vol. 155, no. 3034 and 3035, July 6, and 13, 1921, pp. 35-40 and 101-103, 22 figs. The Simmance recording calorimeter.

**Solid Fuel.** The Calorimetry of Solid Fuel—II. Eng. & Indus. Management, vol. 5, no. 26, June 30, 1921, pp. 737-739, 3 figs. Operating method of some of best-known solid fuel calorimeters are explained and explanitory diagrams are given.

**CAR LIGHTING**

**Testing.** Principles of Car Lighting by Electricity —XII, Charles W. T. Stuart. Ry. Elec. Engr., vol. 12, no. 7, July 1921, pp. 278-282, 7 figs. Testing and adjusting a car-lighting equipment.

**CAR WHEELS**

**Failures.** Studies Failures of Cast-Iron Wheels, H. J. Force. Foundry, vol. 49, no. 15, August 1, 1921, pp. 602-603. Limits recommended for composition of metal based on analyses of failures.

**CARBOCOAL**

**Smith Carbonization Process.** The Smith Continuous Carbonization Process. Engineering, vol. 112, no. 2900, July 29, 1921, pp. 175-179, 10 figs. Describes process developed by C. H. Smith, New York, according to which coal is first subjected to low-temperature distillation, after which solid residue is again treated at high temperature to produce hard fuel known as carbocoal. Details of plant at Clinchfield, Va.

**CARBURETORS**

**Automaticity.** Principles of Automatic Action In Carburetors (Les Principes d'Automaticité des Carburateurs). La Vie Automobile, vol. 17, no. 732, June 25, 1921, pp. 223-225, 6 figs. Discusses supplementary air supply, simultaneous control of air and gasoline flow, diffusers, etc.

**Fundamentals.** Fundamental Points of Carbureter Action, F. C. Mock. Jl. Soc. Automotive Engrs., vol. 9, no. 2, August 1921, pp. 85-94, 11 figs. Considers the joint responsibility of the engine designer and the carbureter engineer, and of the latter to produce an instrument that will deliver reliably and consistently a fuel charge with as favorable vaporization conditions as can be obtained.

**CARS**

**All-Metal.** New All-Metal Cars in Use on English Railway, F. C. Coleman. Elec. Traction, vol. 17, no. 7, July 1921, pp. 468-470, 3 figs. Cars built by Lancashire & Yorkshire Ry. Details of electrical equipment; automatic control; brake equipment; and interior construction.

**All-Steel High-Capacity.** New All-Steel Wagons for Bengal-Nagpur Railway. Ry. Engr., vol. 42, no. 498, July 1921, pp. 273-275, 4 figs. Details of high-capacity wagons constructed by Midland Ry. Carriage & Wagon Co., Ltd., Birmingham, for India. Dimensions: Extreme length over buffers, 49 ft. 2 in.; width over underframe solebars, 9 ft. 6 in.; center of bogies, 32 ft.; bogie wheelbase, 6 ft.; buffer height, 3 ft. 7 1/2 in.; load, 40 tons.

**Dining.** New Dining and Kitchen Carriages Built at Derby for the Midland and Glasgow & South Western Railways' Joint Services. Ry. Gaz., vol. 35, no. 3, July 15, 1921, pp. 128-137, 12 figs. 1 supp. pl. Particulars of dimensions and equipment.

**Suspension Method.** Study of a New Suspension Method for Railway Cars, (Etude d'une nouvelle Suspension pour Matérial Roulant), M. Lotte. L'Industrie des Tramways, vol. 15, no. 171-172, March-April 1921, pp. 51-53, 1 fig. (Concluded.)

**CARS, FREIGHT**

**Concrete.** New Reinforced-Concrete Freight Cars (Neue Eisenbahnwagenbauten in Eisenbeton), Gerhard Neumann and Franz Lehner. Beton u. Eisen, vol. 20, no. 2-3, Feb. 4, 1921, pp. 32-34, 6 figs. Details of the first Hungarian reinforced-concrete cars type Kmn; and the Austrian cars type Ke.

**Design.** Factors To Be Considered in Freight Car Designing, Albert H. Lake, Jr. Ry. Mech. Engr., vol. 95, no. 8, August 1921, pp. 495-496. Arranging details to reduce cost of construction and maintenance and avoiding troublesome defects.

**Draft-Gear Tests.** Draft-Gear Tests of the Railroad Administration. Ry. Mech. Engr., vol. 95, no. 8, August 1921, pp. 497-501, 8 figs. Results of car impact tests, comparative grading of gears and general conclusions.

**CARS, TANK**

**Reinforced-Concrete.** Reinforced-Concrete Tank Cars (Zisternenwagen aus Eisenbeton), Viktor Lazarus. Beton u. Eisen, vol. 20, no. 6, Apr. 4, 1921, pp. 69-70, 4 figs. Details of French tank cars of reinforced concrete for transportation of petroleum, wine, etc.

**CASE-HARDENING**

**High-Temperature Resisting Alloys.** High Temperature Resisting Alloys for Carbonizing, A. Bensel. Trans. Am. Soc. Steel Treating, vol. 1, no. 10, July 1921, pp. 598-601. Sets forth desirability of good heat-resisting containers, and discusses standard methods of case hardening employing these containers, namely, pack, liquid bath and gas carbonizing.

**CAST IRON**

**Shrinkage and Piping.** The Shrinkage and Piping of Cast-Iron (Schwinden und Lunkern des Eisens), Karl Sipp. Stahl u. Eisen, vol. 41, no. 26, June 30, 1921, pp. 888-890, 2 figs. Supplement to author's article in same journal (Apr. 24, 1921, pp. 675-680), in which theory of shrinkage and piping was developed.

**Spiegeleisen, Influence of.** Influence of Speigeleisen and Phosphorus Spiegeleisen on Cast Iron (Einfluss von Spiegel- bzw. Phosphorspiegeleisen auf das Gusseisen), E. Schultz. Giesserei-Zeitung, vol. 18, nos. 10 and 12, May 15 and June 15, 1921, pp. 152-155 and 197-200, 3 figs. Based on operating experiences in the Luise Mine in Lünen, Germany, writer explains effect of increase in content of manganese in charge in connection with melting in cupolas caused by addition of spiegeleisen and phosphorus spiegeleisen. Address delivered before Assn. German Steel Works Engrs.

**CASTINGS**

**Cracks, Annular.** Annular Cracks, R. R. Clarke. Metal Industry (Lond.), vol. 19, no. 1, July 1, 1921, pp. 2-3, 10 figs. Discussion of various theories accounting for their formation.

**CEMENT**

**Hardening.** Law of Hardening of Cement, (Loi de durcissement du Ciment), J. Bied and E. Garnier, Revue de l'Ingénieur, vol. 28, no. 6, June 1921, pp. 269-272, 1 fig. Graph constructed from results of experiments.

**Oxychloride.** Plastic Calcined Magnesite and Oxychloride Cements, M. Y. Seaton. Chem. & Met. Eng., vol. 25, no. 6, August 10, 1921, pp. 233-236, 1 fig. Physical tests showing and factors influencing the properties of oxychloride cements.

**Rapid-Setting.** Rapid-Setting Cement (Béton à pris accélerée des fermes du Comptoir suisse d' Echantillons de Beaulieu), A. Paris. Bulletin Technique de la Suisse Romande, vol. 47, no. 15, July 23, 1921, pp. 169-172, 7 figs. Results of tests carried out with Holderbank cement to produce a cement which will harden in ten days instead of the usual 28.

**Tests.** Tests for the Determination of the Variations of Volume of Cement and Cement Mortar During Setting (Versuche zur Ermittlung der Raumänderungen von Zement und Zementmörtel beim Abbinden, Etc.), Otto Graf. Beton u. Eisen, vol. 20, nos. 4-5 and 6, Mar. 7 and Apr. 4, 1921, pp. 49-52 and 72-74, 12 figs. Influence of water addition, mixture ratio, and cement on extent of volume variations. Measurement of change of length of reinforcement with setting of cement mortar. Investigations of the swelling and contracting of natural stones with moisture and by drying.

**CEMENT, PORTLAND**

**Crushing Plant.** Perfect Dry-Mix Control. Rock Products, vol. 24, no. 15, July 16, 1921, pp. 20-28, 29 figs. Details of new crushing plant of Giant Portland Cement Co. at Egypt, Pa.

**Coal-Fired.** The Economic Limits of Distribution from Coal-fired Stations, William B. Woodhouse. Engineering, vol. 112, no. 2898, July 15, 1921, p. 128, 1 fig. Consideration of steps to be taken to supply an area which extends beyond economical limits of distribution pressure in use. Paper read before Instn. Civ. Engrs.

**Equipment.** Modern Tendencies in Central Station Construction (Les Tendences Modernes dans la Construction des Centrales), F. Scoumanne. Revue Universelle des Mines, vol. 9, no. 4, May 15, 1921, pp. 346-355. Describes machinery and switchboard equipment.

**CHIMNEYS**

**Brick, Loss of Heat in.** Loss of Heat in Brick Chimneys, Alfred Cotton. Power Plant Eng., vol. 25, no. 15, August 1, 1921, pp. 747-748. An investigation into the effect of air infiltration on heat loss.

**COAL**

**Volatile Content.** Determination of Volatile Matter in Coal (Determination de la Teneur en Matières Volatiles), Auguste Dessemond. Revue de l'Industrie Minerale, no. 13, July 1, 1921, pp. 451-456. Develops a formula for calculating volatile matter from ash content.

Volatile Matter in Coal (Les Matières Volatiles de la Houille), Achille Delclève. Chimie & Industrie, vol. 6, no. 1, July 1921, pp. 33-40, 5 figs. Shows that present methods require revision.

**COAL HANDLING**

**Plant.** A Modern Coal-Handling Plant. Managing Engr., vol. 8, no. 3, July 1921, pp. 47-52, 6 figs. Describe a mechanical coal-handling plant that involves avoidance of waste and will operate day and night, so long as the necessary driving power is available.

**Pneumatic Plant.** The Pneumatic Handling of Coal. Elecn., vol. 86, no. 2249, June 24, 1921, pp. 801-803, 4 figs. Describes pneumatic plant for discharging coal from barges, constructed by Henry Simon, Ltd.

**COAL STORAGE**

**Submerging in Pits.** Concrete Pits for Submerging Reserve Coal Supply. Elec. Rev., vol. 79, no. 5, July 30, 1921, pp. 163-164, 2 figs. Dangers of spontaneous combustion are eliminated and drippage basin is provided by means of which screenings are saved.

**COKE**

**Foundry Slag and, Characteristics of.** Characteristics of Foundry Cokes and Slags, Y. A. Dyer. Iron Age, vol. 108, no. 7, Aug. 18, 1921, pp. 407-409. Analyses, units of value and tests. Analyses and value of fluxes. Slagging. Nature of slags and value of melting process.

**COKE BREEZE**

**Boiler Fuel.** Coke Breeze Mixtures for Steaming —II, John Blizzard and James Neil. Coal Trade Jl., vol. 52, no. 29, July 20, 1921, pp. 845-846, 2 figs. Tests show advantages of combining breeze with bituminous coal under hand-fired boilers.

Burning Coke Breeze with Mechanical Stokers, William H. Burton. Coal Industry, vol. 4, no. 7, July 1921, pp. 331-333. Successful handling of low-grade fuels in a boiler plant.

**COKE-OVEN GAS**

**Benzol in.** Determination of Benzol in Coke-Oven Gas, A. Thau. Part I. Blast Furnace & Steel Plant, vol. 9, no. 8, August 1921, pp. 474-476, 1 fig. Describes European methods of determining benzol. (To be continued.)

**COLUMNS**

**Design.** Calculation of Columns (Le Calcul des Colonnes), L. Lemaire. Annales des Travaux Publics de Belgique, vol. 22, series 2, June 1921, pp. 367-384, 12 figs. Develops formulas for wind pressures. (To be continued.)

**Fire-Resistance Tests.** Fire Resistance of Building Columns as Shown by Test, R. E. Wilson. Eng. News-Rec., vol. 87, nos. 3 and 4, July 21 and 28, 1921, pp. 106-110 and 145-146, 5 figs. Conclusions drawn from test series of 106 columns caried out during 1917-18 show cast iron and timber resist longer than unprotected steel. How various fireproofing materials fail. Concrete makes best showing.

**COMBUSTION**

**Alignment Charts for Fuel.** Calculating Charts for the Combustion of A Given Fuel (Rechentafeln für die Verbrennung beliebiger Brennstoffe), Wa. Ostwald. Feuerungstechnik, vol. 9, no. 19, July 1, 1921, pp. 173-177, 9 figs. Writer develops a universal alignment chart which can be used directly for every fuel, or from which special charts can be plotted.

**Control.** Report of the Exposition of Combustion-Controlling Devices (Compte Rendu de l'Exposition des Appareils de Controle de la Chauffe), P. Frion. Société des Ingénieurs Civils de France, vol. 74, nos. 1, 2, 3, January-March 1921, pp. 7-34, 21 figs. Covers manometers, flow meters, feedwater meters, thermometers and pyrometers, flue-gas analysis, calorific power of coal, etc.

**CONCRETE**

**Age, Effect of.** Effect of Age on the Strength of Concrete, Duff A. Abrams. Concrete, vol. 19, no. 1, July 1921, pp. 14-15, 2 figs. Based on careful study of available data, writer states with utmost confidence that under normal conditions, concrete in roads does not deteriorate in strength with age.

**Aggregates.** A Study of the Composition of Blast-Furnace Slags Suitable for Concrete Aggregate, L. G. Carmick. Eng. & Contracting, vol. 56, no. 4, July 27, 1921, pp. 82-83, 2 figs. Describes tests made for the purpose.

**Crusher Screenings, Effect of.** Effect of Crusher Screenings in Concrete, Walter C. Adams and James G. Ross. Cement News, vol. 33, no. 7, July 1921, pp. 19-21, 1 fig. Increase in strength of concrete

through use of up to 20 per cent of crusher screenings in aggregate. Economic advantage of utilizing screenings. Report on tests carried out by Milton Hersey Co., Ltd., Montreal.

**Elasticity, Modulus of.** The Modulus of Elasticity on Concrete, F. C. Lea. Concrete & Constructional Eng., vol. 16, no. 7, July 1921, pp. 435–439 and (discussion) pp. 439–441. 2 figs. Results from compressometer tests show that mixtures in which ration of sand to stone are 1:1 and 1:1½ are not to be recommended, but only mixtures with ratio of 1 : 2, properties of which are summarized. (Abstract.)

**Proportioning.** Proportioning Concrete By Voids in the Mortar, Arthur N. Talbot. Eng. News-Rec., vol. 87, no. 4, July 28, 1921, pp. 147–152, 8 figs. Proposed method of estimating density and strength of concrete and of proportioning materials by experimental and analytical consideration of voids in mortar and concrete. (Abstract.) Paper presented before Am. Soc. for Testing Materials.

Three Methods of Proportioning Concrete. Eng. & Contracting, vol. 56, no 4, July 27, 1921, pp. 87–91, 12 figs. Discusses Abrams' water-cement-ratio strength relation, Edward's surface area method of proportioning, Hydro-Electric Power Commission method of proportioning.

**Setting Time.** Time of Set of Concrete, Watson Davis. Eng. & Contracting, vol. 56, no. 4, July 27, 1921, pp. 79–81. Considers the influence of character of cement, also time and temperature, flow-set method, etc.

**Waterproofing.** Waterproofing Concrete—III, J. H. Burgess. Commonwealth Engr., vol. 8, no. 10, May 1, 1921, pp. 306–307. Notes on permeability tests. (Concluded.)

### CONCRETE, REINFORCED

**Design.** Suggestions for Concrete Design, Harold A. Axtell. Can. Engr., vol. 40, no. 26, June 30, 1921, pp. 1 and 5, 2 figs. Types of live loads for different buildings. Standardization of design. Three systems of slab design and their relative cost.

### CONDENSERS, STEAM

**Cleaning Tubes.** Cleaning Surface Condenser Tubes D. W. R. Morgan. Elec. Jl., vol. 18, no. 7, July 1921, pp. 313–315, 7 figs. Discusses eight types and methods of cleaning.

**Corrosion.** Corrosion in Condensers, Ernest Bate. Commonwealth Engr., vol. 8, no. 11, June 1, 1921, pp. 339–343, 8 figs. Discusses results of investigation and experiments of the condensers of the Ultimo & White Bay power houses, Sydney, N.S.W.

### CONVEYORS

**Belt.** Interlocking Belt Conveyor System, A. M. Beebe. Gas Age-Rec., vol. 48, no. 3, August 6, 1921, pp. 105–107, 7 figs. Description of the electrically driven automatic system of the Rochester Gas & Electric Corp.

### COST ACCOUNTING

**Construction Work.** Cost Accounting System for Construction Work, W. N. Connor. Eng. & Contracting, vol. 56, no. 3, July 20, 1921, pp. 66–70, 9 figs. Notes on use of daily labor cost reports; summary and analysis of estimate; timekeeping symbols and field sheet; waste and payroll sheets; invoice and material cost records; tabulating job cost by graphic method; final cost summary and cost comparison. (Abstract.) Paper presented before Boston Soc. Civ. Engrs.

**Foundries.** The Costing Problem in the Foundry, O. Bertoya. Metal Industry (Lond.), vol. 19, no. 2, July 8, 1921, pp. 21–24. Notes on indirectly apportionable expenses and overhead charges; inspection; and records.

**Methods.** Necessity of Proper Cost Accounting, J. B. Sehl. Iron Age, vol. 108, no. 7, Aug. 18, 1921, pp. 391–393. Machine-rate or production-center method stressed. Distribution of overhead in bulk or by department. Why some methods fail.

**Principles and Advantages.** The Necessity of Proper Cost Accounting, J. B. Sehl. Forging & Heat-Treating, vol. 7, no. 7, July 1921, pp. 370–372. Describes principles of cost accounting and explains its advantages. Primary purposes of cost accounting are summarized as follows: (1) to ascertain actual costs; (2) to forecast in order to fix future selling prices; (3) to reduce costs; and (4) to increase efficiency.

**Work-in-Progress Account.** The Work-in-Progress Account: An Essential Feature in Modern Costing. Robert Stelling. Eng. & Indus. Management, vol. 5, no. 26, June 30, 1921, pp. 734–736, 1 fig. Notes on relation of turnover and finances, cost of idle time, etc.

### COSTS

**Engineering, Rise in.** Rise in Engineering Costs—II, R. J. A. Pearson. Eng. & Indus. Management, vol. 5, no. 26, June 30, 1921, pp. 740–742, and vol. 6, no. 1, July 7, 1921, pp. 11–13, 5 figs. Data contained in paper read before Roy. Statistical Soc. on comparison of pre-war and post-war costs in engineering.

### CRANES

**Floating.** Derricking Jib Type Floating Crane Mammouth. Marine Eng., vol. 26, no. 8, August 1921, pp. 591–592, 2 figs. 200-ton floating crane for the port of Liverpool.

**Foundry.** 25-ton Electric Overhead Foundry Crane. Engineer, vol. 131, no. 3417, June 24, 1921, pp. 667–668, 5 figs. Span is 47 ft. between centers of rails, maximum available head room 7 ft. 10 in. and end clearance 10 in.

Handling Materials in a Remodeled Foundry. Iron Age, vol. 108, no. 2, July 14, 1921, pp. 76–78, 4 figs. New crane installations saved in a year over double their cost.

**Safety Devices.** Crane Safety Devices, Nicholas Prakken. Safety Eng., vol. 42, no. 1, July 1921, pp. 27–30. Deals with safety devices on class of cranes used in foundries, machine shops, yards, shipways and warehouses.

**Traveling.** Electric Motor Drive for Traveling Cranes, Gordon Fox. Blast Furnace and Steel Plant, vol. 9, nos. 7 and 8, July and Aug. 1921, pp. 413–416 and 485–488, 3 figs. Discusses question of manual control versus magnetic control for cranes.

**Wharf.** Motor-Operated Cranes Used for Cargo Transfer, Henry Cunningham. Elec. Rev. (Chicago) vol. 79, no. 3, July 16, 1921, pp. 90–92, 2 figs. Describes two Shaw overhead wharf cranes installed at pier on East River, New York City.

### CUPOLAS

**Chemical Reactions.** Chemical Reactions in Foundry Cupolas, Y. A. Dyer. Iron Age, vol. 108, no. 5, Aug. 4, 1921, pp. 259–262. Actions and reactions. Combustion, cupola gases, carbon ratio, melting efficiency, metal losses and gains. Cupola balance sheet.

**Use in Open-Hearth Practice.** Use of Cupolas in Open-Hearth Practice, V. W. Aubel. Iron Age, vol. 108, no. 7, Aug. 18, 1921, pp. 403–405. Melting high-silicon and other pig iron continuously and supplying hot metal to four 60-ton basic open-hearth furnaces.

### CUTTING TOOLS

**Lathe and Planer.** Design of Lathe, Planer, Shaper and Slotter Tools. Can. Machy., vol. 26, no. 3, July 21, 1921, pp. 33–36, 10 figs. Factors which decide what shape of tool will prove most efficient for any given cutting operation.

The Lumsden System for Lathe-Type Tools. Engineering, vol. 112, nos. 2900 and 2901, July 29 and Aug. 5, 1921, pp. 183–186 and 213–216, 17 figs. Details of the Lumsden oscillating grinder with settings required for some of the tools given in table.

### CYLINDERS

**Calculation.** The Calculation of Thick and Thin Cylinders. Machy. (Lond.), vol. 18, no. 458, July 7, 1921, pp. 421–422, 5 figs. Calculating method and examples.

### DIES

**Trimming.** Construction and Action of New Trimming Die. Can. Machy., vol. 25, no. 24, June 16, 1921, pp. 40–41, 4 figs. Describes patented tool that trims surplus metal. In place of downward movement of punch a lateral oscillating movement accomplishes operation.

### DIESEL ENGINES

**Construction.** Building Diesel Engines on the Pacific Coast, Frank A. Stanley. Am. Mach., vol. 55, no. 2, July 14, 1921, pp. 41–43, 12 figs. How principal parts are machined. Good system for keeping order in shop handling big work.

**Generator Driving.** Diesel Engines for Generator Driving, C. S. Darling. Beama, vol. 9, no. 1, July 1921, pp. 41–45. Construction, operation, maintenance, etc. (Concluded.)

**Investigations.** Investigations of Diesel Engines—II (Untersuchungen an der Dieselmaschine), Kurt Neumann. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 30, July 23, 1921, pp. 801–804, 10 figs. Results of tests for determination of condition during combustion period and interchange of heat between gas and wall of engine cylinder. The separate phases of combustion are quantitatively determined, and the speed of combustion is established.

**Lubrication.** Lubrication of Marine Diesel Engines, Louis R. Ford. Marine Eng., vol. 26, no. 8, August 1921, pp. 623–627, 4 figs. Discusses low-pressure and high-pressure systems, cylinder lubrication, selection of oil, oil filters, etc.

**Manufacture.** Four-Cycle Diesel Engine Specialists. Steamship, vol. 33, no. 385, July 1921, pp. 15–21, 9 figs. Notes on manufacture of Diesel engines by firm of Burmeister & Wain, Ltd., Copenhagen. Gives list of motorships built by firm.

**Marine.** Injection and Combustion of Fuel-Oil, Part V., C. J. Hawkes. Motorship, vol. 6, no. 8, August 1921, pp. 655, 1 fig. Experiments with solid-injection and air-blast in marine Diesel engines. (To be continued.)

Problems in the Manufacture of Internal-Combustion Engines, John Holloway. Shipbuilding & Shipping Rec., vol. 18, no. 1, July 7, 1921, pp. 13–14. Suggestions on choice of material and best methods of machining various parts of marine Diesel engines.

The Use of Diesel Engines for the Drive of Deep-Sea Fishing Vessels (Verwendung von Dieselmotoren als Antriebsmaschinen für Hochsee-Fischereifahrzeuge), H. Wölke. Schiffbau, vol. 22, no. 38–39, June 22–29, 1921, pp. 917–921, 4 figs. Writer points out advantages and recommends replacing steam engines in older fishing steamers with former U-boat Diesel engines or with described 250-hp. Diesel engine.

**Nobel.** Development of the Nobel Diesel-Engine, Edwin Lundgren. Motorship, vol. 6, no. 8, August 1921, pp. 648–649, 4 figs. Reviews past work and describes progress of the two-cycle system. (To be continued.)

**Recent Progress.** Recent Progress in Large Diesel Engines for the Mercantile Marine, James Richardson. Engineering, vol. 112, no. 2899, July 22, 1921, p. 168. Includes list of important Diesel ships in service and building, giving particulars of their machinery. Paper read before Institution of Civil Engineers.

## D

### DISKS

**Spinning, Vibrations of.** The Vibrations of a Spinning Disk, H. Lamb, and R. V. Southwell. Proc. Royal Soc., vol. 99, no. A 699, July 1, 1921, pp. 272–280. Treats of the transverse vibrations of a circular disk of uniform thickness rotating about its axis with constant angular velocity.

### DRILLING MACHINES

**Horizontal.** Recent Machine Tool Developments—XX, Joseph Horner. Engineering, vol. 112, no. 2897, July 8, 1921, pp. 33–36, 20 figs. 13 on supp. plate. Horizontal boring and drilling machine constructed by Cunliffe & Groom, Ltd., Manchester, England.

**Radial.** A New Radial Drilling Machine. Eng. Production, vol. 3, no. 40, July 7, 1921, p. 19, 1 fig. Describes new machine manufactured by Kitchen & Wade, Halifax, of low-base type, baseplate of which is of deep section, well ribbed and planed both top and bottom.

### DRILLS

**Tap.** Tap Drill Sizes, E. C. Peck and T. F. Githens. Am. Mach., vol. 55, no. 5, Aug. 4, 1921, pp. 194–196, 4 figs. Elements to be considered. What constitutes government standard. Minimum and maximum limits for tap holes. Determining ideal drill size.

### DROP FORGING

**Cost Analysis.** Analysis of Costs of Drop-Forging, R. T. Herdegen. Iron Age, vol. 108, no. 6, Aug. 11, 1921, pp. 325–326. Comparison of steam and board drop hammers. Rate of production studied as well as costs. Dividing line established between types.

**Economical Shop Practice.** Cutting Costs in a Drop Forge Shop, F. L. Prentiss. Iron Age, vol. 108, no. 7, Aug. 18, 1921, pp. 385–388, 6 figs. Trolley system used for handling work between hammers and furnaces. Features include water-reclaiming plant.

**Plants.** Modern Drop Forge Plant Completed, E. C. Cook. Forging & Heat Treating, vol. 7, no. 7, July 1921, pp. 364–369, 14 figs. The Pittsburgh Knife & Forge Co's. new plant at Coraopolis, Pa., is said to incorporate latest ideas in design for production of special parts. Complete plant layout is given.

### DUST

**Dust-Removal Plants.** Modern Dust-Removal Plants (Neuerungen auf dem Gebiete der Entstaubung und Staubförderung), H. Klug. Fördertechnik u. Frachtverkehr, vol. 14, nos. 4 and 5, Feb. 18 and Mar. 4, 1921, pp. 43–46 and 60–62, 7 figs. Describes the Delbag dust-removal and air filter plant in the grinding and polishing works of the Fritz Heckert Glass Factory, Petersdorf.

## E

### EDUCATION, ENGINEERING

**Gas Course.** University of Michigan Gas Course, J. Gerald Ames. Gas Age, vol. 48, no. 2, July 25, 1921, pp. 45–49. Course established under Prof. A. H. White and under patronage of Mich. Gas Assn.

**Prerequisites to Technical Study.** Engineering Courses Should Be of Professional Grade, Wm. H. Burr. Eng. News-Rec., vol. 87, no. 2, July 14, 1921, pp. 65–66. Argues that technical study should be preceded by three years of general college work. (Abstract.) Paper read before Soc. for Promotion of Eng. Education.

### ELASTICITY

**Elastic Limit.** The Elastic Limit, William E. Dalby. Engineering, vol. 112, no. 2897, July 8, 1921, p. 81, 3 figs. Points out that limit of proportionality of material is not a fixed point, but varies with heat treatment and vanishes with overstrain. Paper read before Instn. Civ. Engrs.

### ELECTRIC DRIVE

**Blooming Mill.** Electric Drive for Blooming Mill Service, B. M. Jones. Power Plant Eng., vol. 25, no. 14, July 15, 1921, pp. 721–724, 6 figs. Bethlehem Steel Co. discards steam engine; results gratifying.

**Paper Mills.** Electric Driving in the Paper Mill, on Heat-Economy Lines, A. B. Mallinson. Jl. Instn. Elec. Engrs., vol. 59, no. 301, May 1921, pp. 538–553 and Discussion pp. 553–563, 10 figs. Discusses uses of steam in paper manufacture, classes of machinery driven, including suitable electrical gear, driving of the variable-speed end of paper machine. Table of machines converted to electrical working in the United Kingdom.

### ELECTRIC FURNACES

**Heat-Treating.** Automatic Heat-Treating Furnaces, Gilbert L. Lachter. Iron Age, vol. 107, no. 26, June 30, 1921, pp. 1754–1755, 4 figs. Charging, treating, quenching and drawing performed and governed by automatic devices easily set.

Electric Furnace Treatment of Dies and Forgings, E. F. Collins. Forging & Heat Treating, vol. 7, no. 7, July 1921, pp. 387–392, 7 figs. Describes different types of furnaces. Paper presented at Am. Drop Forge Convention, Chicago.

**Induction.** New Type of Induction Electric Furnace. Iron Age, vol. 108, no. 6, Aug. 11, 1921, pp. 344–346, 6 figs. Primary winding above bath. Experience with 2-ton unit. For refining molten metal and serving as holding reservoir and melting ferromanganese.

**Laboratory Types.** Electric Furnace—I, Ezer Griffiths. Beama, vol. 9, no. 1, July 1921, pp. 12–18, 4 figs. Laboratory types. Notes on resistor, iridium tube, zirconia, and tube furnaces.

**Resistance Type.** Electric Furnace Heat Treatment, E. F. Collins. Iron Age, vol. 108, no. 5, Aug. 4, 1921, pp. 266–267 and (discussion) pp. 267–268. Dies and forgings said to be well handled in metallic resistor furnaces. Uniformity of product a big feature. (Abstract.) Paper read before Am. Drop Forge Assn.

**Steel.** Electric Furnaces for Making Steel, Alfred Stansfield. Blast Furnace and Steel Plant, vol. 9, nos. 7 and 8, July and Aug. 1921, pp. 424–425, 2 figs., and 488–489, 2 figs. General features and advantages of Keller furnace and Stobie furnace. Classification of electric steel-making furnaces. Advantages of electrode hearth arc furnaces having single arc and one movable electrode.

**ELECTRIC HEATERS**

**Immersion Type.** Application and Use of Immersion Electric Heaters, John M. Striat. Elec. Rev., (Chicago), vol. 79, no. 5, July 30, 1921, pp. 161–163, 4 figs. Particulars of installing, size and capacity, precautions to be observed.

**ELECTRIC LOCOMOTIVES**

**Industrial.** Industrial Electric Locomotives. Engineer, vol. 131, no. 3417, June 24, 1921, pp. 666–667, 3 figs. Types built by English Electric Co.

**Mechanical Advantages.** Mechanical Advantages of Electric Locomotives Compared with Steam, Vincent L. Raven. Engineering, vol. 112, no. 2899, July 22, 1921, pp. 164–165. Summarizes mechanical disadvantages of steam locomotive, and discusses fuel economy made possible by use of electric locomotives, together with maintenance costs, and various designs of electric locomotives depending upon method adopted to transmit power from motors to driving axles. Paper read before Instn. Civ. Engrs.

**Steam vs.** Electric Shunting Locomotives. Tramway & Ry. Wld., vol. 50, no. 3, July 14, 1921, pp. 11–13, 3 figs. Describes the advantages of electric over steam locomotives.

**Switching.** B.T.H. Electric Shunting Locomotives. Elec. Rev. (Lond.), vol. 89, no. 2275, July 1, 1921, pp. 27–28, 2 figs. Details of a 10-ton and 22-ton shunting locomotive weighing 56 tons each and fitted with 90-hp. motors, which can start a train weighing 160 tons on a grade of 1 in 27 and haul it on grade 10 mi. per hr.

**ELECTRIC PLANTS**

**Temperature Measurement.** Measuring Temperatures in Electric Installations (La Mesure des Températures dans les Installations Electriques), M. Henry. L'Industrie Electrique, vol. 30, no. 698, July 25, 1921, pp. 265–270, 7 figs. Describes various thermometers and thermocouples and other indicators.

**ELECTRIC POWER**

**Industrial Load, New York State.** Industrial Load in the State of New York. Elec. World, vol. 78, no. 5, July 30, 1921, pp. 207–210, 3 figs. Amount of electrical energy used in New York State has increased over 100 per cent since 1914.

**ELECTRIC WELDING**

**Oil Tanks.** The Electric Welding of Oil Storage Tanks, William Schenstrom. Ry. Elec. Engr. vol. 12, no. 7, July 1921, pp. 267–271, 6 figs. Welded construction eliminates loss from leakage and it is estimated tanks will outlast riveted containers. (Abstract.) Paper presented before Am. Welding Soc.

**Percussive.** Electric Percussion Welding, (La Soudure Électrique Par Percussion), L'Industrie Electrique, vol. 30, no. 696, June 25, 1921, pp. 229–231. Applications and advantages of this process.

**ELECTRIC WELDING, ARC**

**Advantages.** Electric Arc Welding, Henry M. Sayers. Tramway & Ry. Wld., vol. 50, no. 3, July 14, 1921, pp. 25–29, 12 figs. Notes on its increased use, successes, difficulties and failures.

**Cost Data.** Notes on Electric Arc Welding, H. L. Unland. A.S.R.E. Jl., vol. 7, no. 6, May 1921, pp. 426–430 and (discussion) pp. 430–431. Gives cost figures for arc welding and a comparison between gas and electric equipment.

**Heavy Sections.** Welding of Heavy Sections by the Electric Arc. Can. Machy., vol. 26, no. 2, July 14, 1921, pp. 32–33 and 46, 2 figs. Instructions for preparing work to be welded. Welding of cast iron is classed under four heads. (Abstract.) Book entitled Electric Arc Cutting and Welding, published by Elec. Arc Cutting & Welding Co., Newark, N. J.

**EMPLOYEES**

**Care of.** The Human Machine in Industry, Walter J. Matherly. Am. Mach., vol. 55, no. 6, Aug. 11, 1921, pp. 226–227. Care of human machine as important as care of machines of metal. Length of working day. Periods of rest. Fuel.

**EMPLOYMENT MANAGEMENT**

**Psychotechnical Tests.** Psychotechnical Adaptability Tests and Their Use in Metallurgical Works (Die psychotechnische Eignungsprüfung und ihre Anwendung auf Hüttenbetriebe). Stahl u. Eisen, vol. 41, no. 24, June 16, 1921, pp. 822–827. Contributions by H. Hüttenhain, Heinrich Roser, and Hans Daiber. Report of the Machine Committee of the Assn. German Steel Works Engrs.

**EXECUTIVES**

**Training.** Coöperating to Educate a Community's Executives, H. C. Stevenson. Factory, vol. 27, no. 2, August 1921, pp. 182–187, 4 figs. Describes efforts of Rochester Industrial Management Council in this direction.

**EXHAUST STEAM**

**Oil Removal from.** Eliminating Cylinder Oil from Exhaust Steam, W. H. Wakeman. Power Plant Eng., vol. 25, no. 15, August 1, 1921, pp. 749–752, 8 figs. Discusses the essential features in a separator to give satisfactory results.

**Utilization.** Exhaust Steam; Its Employment for Power, Heating, Etc., Ernest Richard Dolby. Engineering, vol. 112, no. 2897, July 8, 1921, p. 74. Notes on better utilization of heat in steam. In author's opinion, most efficient utilization of thermal value in coal cannot be obtained until there are sets of public mains provided by community for public utility. Paper read before Instn. Civ. Engrs.

The Utilization of Exhaust steam in Turbines, Maurice Deacon. Engineering, vol. 112, no. 2899, July 22, 1921, pp. 165–166, 3 figs. Describes general arrangement of mixed-pressure turbine plant. Cost of generating electrical power by exhaust steam is very low due to fact that steam would otherwise be wasted. Paper read before Instn. Civ. Engrs.

**EXTENSOMETERS**

**Calibration.** An Extensometer-Calibrating Device, R. L. Templin. Chem. & Met. Eng., vol. 25, no. 6, August 10, 1921, pp. 248–251, 5 figs. Describes various instruments and methods of operation.

**EVAPORATORS**

**Multiplex Film.** Multiple Effect Evaporation, Burton Dunglinson. Chem. & Metallurgical Eng., vol. 25, no. 3, July 20, 1921, pp. 110–115, 7 figs. Discussion of multiplex film evaporator as regards features of construction and operation. Comparison of multiplex with other types.

**Soderlund-Boberg.** Evaporation by Vapor Compression, Burton Dunglinson. Chem. & Met. Eng., vol. 25, no. 6, August 10, 1921, pp. 246–247, 2 figs. Describes the Soderlund-Boberg evaporator.

# F

**FACTORIES**

**Layout.** Features of German Machine Tool Plant. Iron Age, vol. 108, no. 5, Aug. 4, 1921, pp. 256–258, 6 figs. Color of buildings considered. Prevailing winds aid in reducing dust and noise. Welfare of apprentices and workmen emphasized. Built by Fritz Werner Co., Marienfelde near Berlin.

The Layout of a Modern Machine-Tool Plant, Fred H. Colvin. Am. Mach., vol. 55, no. 5, Aug. 4, 1921, pp. 173–175, 6 figs. Layout of Foote-Burt shop. Receiving material and shipping finished machines. Crane and monorail transport. Overhead hot-water heating system.

**FACTORY MANAGEMENT**

[See INDUSTRIAL MANAGEMENT.]

**FEEDWATER HEATERS**

**Locomotive.** Feed Water Heater and Pump for Locomotives. Engineering, vol. 112, no. 2899, July 22, 1921, pp. 150–151, 8 figs. System adopted by G. & J. Weir, Ltd., Glasgow, is that of exhaust heating only, with a surface heater, a pump being employed to force the feed through heater and into boiler.

**Types.** Selection of Feed Water Heaters for Power Plants, Robert June. Elec. Rev. (Chicago), vol. 79, no. 3, July 16, 1921, pp. 81–84, 4 figs. Relative merits of open and closed heaters. Heated feedwater is said to reduce strains and increase boiler output.

**FERROSILICON**

**Silicon Content.** Effect of Silicon On the Property of Ferrosilicon (Influenza del silicio sulle propreita del ferrosilicio), G. Ongaro. Il Forno Elettrico, vol. 3, no. 5, May 15, 1921, pp. 63–66. Discusses various percentages of Si. Metallurgical effect of various silicon contents.

**FIRE PREVENTION**

**Dust Explosions.** Incandescent Lamps Used in Dust-Laden Atmosphere, D. J. Price & H. R. Brown. Elec. Rev., vol. 79, no. 5, July 30, 1921, pp. 165–166, 1 fig. Shows that they constitute a fire and dust-explosion hazard unless properly installed and adequately protected.

**Explosions of Highly Inflammable Liquids.** Stopping Fires in Highly Inflammable Liquids. Charles H. Meigs. Fire & Water Eng., vol. 70, no. 2, July 13, 1921, pp. 58–59 and 64–65, 3 figs. Effective method of extinguishment. Application of foam system.

**FLOUR MILLS**

**Rolls.** The Manufacture of Chilled Iron Rolls, Am. Miller, vol. 49, no. 8, August 1, 1921, pp. 822–823, 10 figs. Processes employed in producing high grade rolls for flour milling.

**FLOW OF WATER**

**Manning's vs. Kutter's Formula.** Manning's Formula Better Than Kutter's. Eng. News-Rec., vol. 87, no. 3, July 21, 1921, p. 96, 2 figs. H. W. King suggests that an abbreviated form of Kutter's equation, eliminating the *s* or slope terms, will give far more consistent results, and that in his opinion Kutter's formula will give just as satisfactory results without the *s* terms.

**Riveted Steel Pipes.** Flow of Water Through Galvanized Spiral Riveted Steel Pipe, F. W. Greve. Eng. News-Rec., vol. 87, no. 4, July 28, 1921, pp. 159–160, 3 figs. Results of experiments performed in hydraulic laboratory of Purdue University to determine variation of friction loss with velocity for flow; variation in accuracy of four types of piezometer rings; and friction loss compared with that in cast-iron pipes for like conditions of diameter and velocity.

**FOREMEN**

**Classes, Training Leaders for.** Training Leaders for Foremanship Classes, D. J. MacDonald. Am. Mach., vol. 55, no. 7, Aug. 18, 1921, pp. 249–251. Fundamental factors involved in training leaders. Outstanding characteristics of typical foreman. Importance of follow-up work in organizing courses.

**FORGING**

**Costs.** Comparative Analysis of Forging Costs, R. T. Herdegen. Forging & Heat Treating, vol. 7, no. 7, July 1921, pp. 397–399. States that it costs more to operate a 1500-lb. steam drop hammer than to operate a 1600-lb. board hammer; and it is not desirable to install a steam drop smaller than 2500 lb.

**Hand vs. Die Forging.** Die versus Hand Forging (Wann ist Gesenkschmieden, wann Schmieden von Hand wirtschaftlicher?), Ferd. Klages. Betrieb, vol. 3, no. 17, May 25, 1921, pp. 519–521, 8 figs. Investigation of relative merits of hand and die forging, taking into consideration saving in time, wages and material. Discusses favorable effect of swaging on structure of material and possibility of setting up more accurate piece-rate wages.

**Manipulators.** Mechanical Manipulator for Heavy Forgings. Engineering, vol. 112, no. 2899, July 22, 1921, p. 151, 4 figs. partly on p. 154. Machines constructed by Alliance Machine Co., Alliance, Ohio.

**FORGINGS**

**Ingot Sizes for.** Cross-Sectional Dimensions of Steel Ingots for Forged Pieces (Ueber Querschnitts-Abmessungen von Stahlblöcken fur Schmiedestücke), F. Pacher. Stahl u. Eisen, vol. 41, no. 27, July 7, 1921, pp. 913–917 and (discussion) pp 918–919. Deals with faults in forged pieces caused by selection of wrong dimensions of casting mold.

**FOUNDATIONS**

**Bearing Value of Soils.** The Bearing Power of Soils, Arthur L. Bell. Engineering, vol. 112, no. 2898, July 15, 1921, p. 132. Brief outline of progress in theories of earth pressure and bearing value of soils for foundations. Paper read before Instn. Civ. Engrs.

**Concrete.** Foundations, J. C. Hawkins. Power Plant Eng., vol. 25, no. 15, August 1, 1921, pp. 760–762, 5 figs. Templets, forms and process for mixing and placing concrete.

**Pneumatic Caisson.** Pneumatic Caisson Foundations for Tall Buildings, Frank W. Skinner. Compressed Air Magazine, vol. 26, no. 7, July 1921, pp. 10143–10148, 9 figs. Highly developed use of compressed air for building deep and difficult footings impossible to construct by any other method.

**FOUNDRIES**

**Safety Provisions.** Safety in Foundry Equipment, A. R. Bartlett. Mech. Wld., vol. 70, no. 1803, July 22, 1921, pp. 70–72. Discusses danger signs, foundry yard, foundry floor, ventilating and lighting, cranes, chains and slings, etc.

**FRAMES**

**Rigid, Calculation of.** Graphic Investigation of Rectangular Rigid Frames (Zeichnerische Untersuchung rechteckiger Steifrahmen), J. Polivka. Beton u. Eisen, vol. 20, no. 4–5, Mar. 7, 1921, pp. 57–60, 12 figs. Graphic calculating method for determination of the moments and normal forces in closed and fixed-in rigid frames.

**FREIGHT HANDLING**

**Danube River.** Mechanical Freight Loading and Unloading Plants on the Trans-shipment Docks of the First Danube Steam Navigation Co. (Die mechanische Güterumladung auf den Umschlagplätzen der Ersten Donau-Dampfschiffahrts-Gesellschaft), W. Hollitscher. Fördertechnik u. Frachtverkehr, vol. 14, nos. 2, 3, 4 and 5, Jan. 21, Feb. 4, 18 and Mar. 4, 1921, pp. 21–26, 34–38, 46–49 and 62–65, 15 figs. Described plants are distributed over a stretch of 4000 km. Notes on organization, application of principles of scientific management, etc. The technical and commercial organization of the department for loading plants of above-mentioned company is described in detail.

**Mechanical.** Mechanical Freight Handling on the New York Central Lines, William T. Gaynor. Transportation Wld., vol. 3, no. 5, July-August 1921, pp. 11–12, 1 fig. Shows the influence of local conditions on mechanical handling methods.

**Unit Cost Data.** Unit Cost Data Reduce Freight Train Expense, J. E. Hutchison. Ry. Age, vol. 71, no. 4, July 23, 1921, pp. 161–163, 1 fig. Prompt distribution of information aids in cutting wage charges per hundred-ton miles. Shows form used in reporting wage cost of handling trains on St. Louis-San Francisco railway system.

**FRICTION**

**Sliding and Rolling.** The Theory of the Sliding and Rolling Resistance of Solid Bodies (Zur Theorie des Gleit- und Rollwiderstandes der festen Körper), Sigmund Fuchs. Physikalische Zeit., vol. 22, nos. 6 and 7, Mar. 15 and Apr. 1, 1921, pp. 173–177 and 213–218. Explains so-called dry sliding friction of solid bodies through the hydrodynamic friction of air stratum between the bodies; and the friction phenomena between specially cleaned surfaces in a vacuum. The rolling resistance of elastic bodies under assumption of an incomplete elasticity is determined. Discusses cause of so-called slip with rolling of the elastic body; and influence of distribution of mass of rolling body on size of moment of resistance.

**FUELS**

**Colloidal.** Colloidal Fuel. Pac. Mar. Rev., vol. 18, no. 7, July 1921, pp. 394–396, 1 fig. Article compiled from interviews with and printed material submitted by Linden W. Bates, who controls basic patents covering process for colloidalization of oil and fuels. Describes small colloidalizing plant, and points out principal advantages of colloidal fuel.

Colloidal Fuel Applied to Bar-Heating Furnaces Engineering, vol. 112, no. 2898, July 15, 1921, pp. 124–125, 5 figs. Report by J. C. Marble on trials made on rod-heating furnace at Swansea Works of Steel Co. of Canada. Attention is drawn to fact that fuel, though old, showed no signs of sedimentation, and that owing to its specific gravity fire risk was capable of being greatly reduced as compared with oil.

**Future Problems.** Fuel Problems of the Future, George T. Beilby. Gas Jl., vol. 154, no. 3033, June 29, 1921, pp. 737–743; also Gas World, vol. 75, no. 1928, July 2, 1921, pp. 6–8 and 9–10; also Engineering, vol. 112, no. 2896, July 1, 1921, pp. 26–30. Writer points out that coal is likely to remain for a long time the world's chief source of fuel, and its more efficient use may be secured by more careful sorting and preparation of mines; improvement of boiler firing; and sorting out of its combustible constituents into fuels of higher availability or convenience by preliminary carbonization at either high or low temperatures. James Forrest lecture before Instn. Civ. Engrs.

**Industrial Heating.** Selection of Fuel for Industrial Heating. Chem. & Metallurgical Eng., vol. 25, no. 3, July 20, 1921, pp. 116–118, 1 fig. Includes chart showing comparative fuel costs, and table giving characteristics of various industrial gases. (Abstract.) Pamphlet copyrighted by W. S. Rockwell Co.

**Research Station.** The Fuel Research Station at East Greenwich. Gas World, vol. 75, no. 1928, July 2, 1921, pp. 3–4. Notes on work being carried out and significance in connection with gas and fuel problems.

**Substitutes for Coal.** Alternatives to Coal for Power Production, Percy E. Rycroft. Elecn., vol. 86, no. 2249, June 24, 1921, pp. 783–787, 10 figs. Discusses value of refuse destructors, oil, coke, colloidal fuel, lignite, etc., as substitutes.

**Utilization.** University of Public Works, Commission on Utilization of Fuels (Ministère des Travaux Publics, Commission d'Utilisation du Combustible), Revue de l'Industrie Minérale, no. 11, June 1, 1921, pp. 423–426. Continuation of report. (To be continued.)

[See also CARBOCOAL; COAL; COKE; COKE BREEZE; OIL FUEL; PEAT; PULVERIZED COAL; TAR OILS.]

**FURNACES, BOILER**

**Flue-Dust Abatement.** The Formation and Abatement of Flue Dust (Flugaschenbildung und Flugaschenbeseitigung), F. Kaiser. Zeit. des Bayerischen Revisions-Vereins, vol. 25, no. 12, June 30, 1921, pp. 106–108, 2 figs. Discusses various means for prevention and removal of flue dust.

**FURNACES, BRASS-MELTING**

**Natural-Draft Type.** A Type of Natural Draft Melting Furnace—I, Charles Vickers. Brass World, vol. 17, no. 7, July 1921, pp. 197–201, 4 figs. Particulars of construction, types of furnaces and dimensions, location and building of furnaces.

**FURNACES, HEATING**

**Ingot.** The Siemens Regenerative Gas Ingot-Heating Furnace with Divided Flame (Der Siemens-Regenerativ-Gas-Stossofen mit Flammenteilung), Arthur Sprenger. Stahl u. Eisen, vol. 41, no. 22, June 2, 1921, pp. 749–753, 6 figs. Describes regenerative furnace with divided flame and vertical U-shaped flame arch, and points out its adaptability to any given conditions and construction types. It is claimed that the new furnace type will greatly contribute to utilization of low-grade gases with simultaneous recovery of by-products.

**FURNACES, HEAT-TREATING**

**Die Blocks, for.** Furnaces for Heat Treatment of Die Blocks, S. Trood. Forging & Heat Treating, vol. 7, no. 7, July 1921, pp. 393–397, 7 figs. Discusses proper proportioning and mixing of fuel and air, temperature of ignition, time element, velocity and space required by products of combustion and recirculation.

**Molydenum Steel Parts.** Special Heat-Treating Furnaces for Molydenum Steel Parts. Automotive Manufacturer, vol. 63, no. 4, July 1921, pp. 19–21, 4 figs. Description of unusual automatic furnaces installed and principle of operation.

**FUSION WELDING**

**Possibilities.** The Possibilities of Fusion Welding, A. S. Kinsey. Iron Age, vol. 108, no. 6, Aug. 11, 1921, pp. 337–338. Conditions for this type of weld. Control of welders. Test of welds. Success with alloy steels. (Abstract.) Address before Cleveland Section Am. Welding Soc.

# G

**GAGES**

**Economic Selection.** Suggestions for an Economic Selection of Types of Gages from the Systems of Standard Holes and Standard Shafts (Richtlinien für eine wirtschaftliche Auswahl der Lehrenarten aus den Systemen der Einheitsbohrung und der Einheitswelle), K. Gottwein. Betrieb, vol. 3, no. 18, June 10, 1921, pp. 266–273, 10 figs. Author's recommendation is approved by sub-committee of German Industry Committee on Standards (NDI), and is thought to be especially adapted to mixed production, for giving the different firms a basis for selection of the necessary gages for all cases in which the use of unit systems is not required.

**Hoke.** Hoke Gages, Earle Buckingham. Army Ordnance, vol. 2, no. 1, July-August 1921, pp. 36–38, 4 figs. Discusses the importance of accurate gages in the production of munitions.

**Industrial.** Study of Industrial Gages at International Bur. of Weights and Measures. (L'Etude des Calibres Industriels au Bureau international des Poids et Mesures). Le Génie Civil, vol. 78, no. 24, June 11, 1921, pp. 500–503, 9 figs. Standard Gages of Johansson type. Gaging by light-interference method. (Concluded.)

**GAS ENGINES**

**British Type.** Machinery at the Royal Agricultural Show. Engineering, vol. 112, no. 2896, July 1, 1921, pp. 7–10, 6 figs. Details of suction gas producer for wood refuse 50-hp. gas engine constructed by Davey, Paxman & Co., Ltd., Colchester.

**GAS PRODUCERS**

**Operation.** Graphic Investigations in Produce Operation (Graphische Untersuchungen im Generatorbetrieb), W. Claus and L. Neuszel. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 29, July 16, 1921, pp. 769–773, 8 figs. Discusses Ostwald's method for the graphic presentation of performance in producer and describes further use of this method for simple determination of the special properties of producer gases. Exemplifies use of derived tables and recommends a standard international terminology for producer gases.

**GASES**

**Throttling Effect.** The Throttling Effect and Equation of Condition (Drosselwirkung und Zustandgleichung), K. Schreber. Zeit. für komprimierte u. flüssige Gase, vol. 21, nos. 1, 2, 3, 4, 5 and 6, 1920, pp. 1–7, 17–21, 29–33, 44–45, 53–56 and 65–68, 4 figs. Presents equation which can be used to calculate throttling effect when equation of condition is known, or to derive an equation of condition when throttling effect is known.

**GASOLINE**

**Casinghead Gas.** Casinghead Gas. Oil Field Eng., vol. 23, no. 7, July 1921, pp. 70–72. Gives particular of the production of gasoline from casinghead gas.

**Engine, Specifications for.** Problems Involved in Developing Engine Gasoline Specifications, E. W. Dean. Jl. Soc. Automotive Engrs., vol. 9, no. 2, August 1921, pp. 131–132. Gives general properties of satisfactory engine gasoline and specification limits.

**GEAR CUTTING**

**Hobbing Worms.** A Novel Method of Hobbing Worms. Automotive Ind., vol. 45, no. 4, July 28, 1921, pp. 171–172, 3 figs. Uses a helicoidal cutter.

**Methods.** Recent Gear-Cutting Practice—IX. Mech. Wld., vol. 70, no. 1803, July 22, 1921, pp. 58–59, 14 figs. Discusses small spur gears, including internal, and ratchets. (To be continued.)

**Multiple Shapers.** Cuts Teeth of a Gear at One Operation. Iron Age, vol. 108, no. 4, July 28, 1921, pp. 197–200, 7 figs. Stevenson multiple shaper, how it operates and its field.

**Racks.** A New Rack Cutting Attachment. Eng. Prod., vol. 3, no. 44, August 4, 1921, pp. 100–101, 4 figs. Details of a useful device for use on milling machines.

**GEARS**

**Comparator, Gear-Tooth.** The Sykes Gear Tooth Comparator. Machy. (Lond.), vol. 18, no. 459, July 14, 1921, pp. 454–455, 3 figs. For comparing and measuring thickness of gear teeth.

The Sykes Gear-Tooth Comparator. Engineering, vol. 112, no. 2898, July 15, 1921, p. 103, 3 figs. Instrument consists of short bar fitted with one fixed and one sliding jaw, arranged with needle of a dial indicator between the two, and is used for comparison of thickness of gear teeth and uniformity of pitch. Other uses.

**Teeth, Strengthened.** Stengthened Gear Teeth. Eng. Production, vol. 3, no. 41, July 14, 1921, pp. 28–30, 8 figs. Notes on principles applied. Includes summary of various formulas for long addendum gear teeth.

**Testing Machine for Teeth.** The Odontometer for Testing Gear Teeth, Earle Buckingham. Machy. (Lond.), vol. 18, no. 458, July 7, 1921, pp. 412–413, 6 figs. Describes instrument for testing accuracy or uniformity of gear-tooth profiles and spacings of teeth in production work, developed by Pratt & Whitney Co.

**GRAIN ELEVATORS**

**Oakland, Cal.** Bulk Handling of Grain in California, Charles W. Geiger. Ry. Rev., vol. 69, no. 7, August 13, 1921, pp. 205–208, 5 figs. Particulars of a new 1¼-million-bushel elevator at Oakland and others, carloading equipment for bulk grain, etc.

**GRAIN HANDLING**

**Unloader.** Electrically Operated Grain Car Unloaders, R. T. Kintzing. Elec. Jl., vol. 18, no. 7, July 1921, pp. 301–304, 7 figs. Describes car dumpers of Northern Central grain elevator of P.R.R., four of which side by side, with operating crew of 18 men, can unload 400 cars daily, each car containing from 1200 to 2000 bushels of grain.

**GRINDING**

**Automobile Parts.** Grinding the Automotiv ni Industry—I, P. M. Heldt. Automotive Ind., vol. 45, no. 6, August 11, 1921, pp. 265–269, 11 figs. Describes the various kinds of grinding wheels, their selection, cutting speeds, balancing, truing, etc.

**Data.** Recent Data on Grinding Room Production. Abrasive Industry, vol. 2, no. 7, July 1921, p. 241. Data on grinding valves, steel pins, square shafts and valve stems.

**Modern Methods.** The Economy of Modern Grinding Methods, Harlowe Hardinge. Chem. & Met. Eng., vol. 25, no. 6, August 10, 1921, pp. 229–232. Considers high cost of obsolete grinding plant, classification of grinding operations, etc.

**GUNS**

**16-In. 50-Caliber.** 16-Inch 50-Caliber Gun and Barbette Carriage, G. M. Barnes. Army Ordnance, vol. 2, no. 1, July-August 1921, pp. 15–20, 9 figs. Gives particulars of gun and projectiles.

# H

**HANDLING MATERIALS**

**Loading Cars from Boats.** Transshipping Bulk Freight (Umladevorrichtungen), Otto Kümmel. Fördertechnik u. Frachtverkehr, vol. 14, no. 4, Feb. 18, 1921, pp. 49–50, 2 figs. Notes on transshipping gears for bulk freight (coal, ore, gravel, etc.), with utilization of differences in altitude of land in ship-canal locks.

**Pressed-Steel Plant.** Routing of Material Feature of Plant, F. L. Prentiss. Iron Age, vol. 107, no. 26, June 30, 1921, pp. 1741–1745, 5 figs. Youngstown Pressed Steel Co. introduces tunnels under new shops to avoid congestion of traffic. Other operating economies.

**Ship Cargoes.** Speed and Economy Follow Mechanical Handling of Ship Cargoes, Roy S. MacElwee. Transportation Wld., vol. 3, no. 5, July-August 1921, pp. 24–27. Discusses special handling equipment, demountable bodies as an economic factor, tonnage, etc.

**HEAT**

**Mechanical Equivalent.** A New Method of Determining the Mechanical Equivalent of Heat, T. H. Laby & J. K. Roberts. Proc. Royal Soc. of Victoria, vol. 32, Part II, September 1920, pp. 148–155, 8 figs. Describes design and operation of a new apparatus for this purpose in which a copper cylinder is heated by a rotating magnetic field.

**HEAT TRANSMISSION**

**Experiments.** A New Thermal Testing Plate for Conduction and Surface Transmission, F. C. Houghten & A. J. Wood. Jl. Am. Soc. Heat. & Vent. Engrs., vol. 27, no. 5, July 1921, pp. 529–542 and (discussion) pp. 614, 12 figs. Particulars of investigation and results of experiments.

**Liquids and Gases.** Heat Transmission in Liquids and Gases as Function of Velocity (Der Wärmeübergang bei Flüssigkeiten und Gasen als Funktion der Geschwindigkeit), H. Preussler. Stahl u. Eisen, vol. 41, no. 24, June 16, 1921, pp. 827–830. Investigation of influence of velocity of gas and liquids on heat transmission, demonstrating advisability of introducing heat capacity in place of velocity. Formulas for heat transmission through conduction and radiation are tested with regard to their feasibility for steam-boiler and heat-storage calculation.

**Problems.** A Survey of Heat Transmission Problems, W. M. Selvey. Elecn., vol. 87, no. 2250, July 1, 1921, pp. 11–12. Review of trilogy of books by R. Royds entitled, Measurement of Steady and Fluctuating Temperatures; Heat Transmission by Radiation, Conduction and Convection; and Heat Transmission in Boilers, Condensers and Evaporators.

**HEATING AND VENTILATION**

**Westinghouse Works, East Pittsburgh.** Heating Equipment for a Large Industrial Plant, O. H. Bathgate. Heating & Ventilating Mag., vol. 18, no. 7, July 1921, pp. 29–32, 4 figs. Method followed in East Pittsburgh Works of Westinghouse Elec & Mfg. Co.

**HEATING, FACTORY**

**Requirements.** Requirements for Industrial Heating, Harold Fulwider. Elec. World, vol. 78, no. 4, July 23, 1921, pp. 167–169, 2 figs. How to determine power required for ovens and energy consumption per unit of product. Typical calculations for japanning and core-baking ovens. Selection of ventilating equipment.

**HEATING, HOT-WATER**

**Gravity System.** Advanced Ideas Applied in Design of a Gravity Water Heating System, William F. Devendorf. Heat & Vent. Mag., vol. 18, no. 8, August 1921, pp. 25–28, 5 figs. Describes an installation that circulates hot water through supply mains at all times.

**HELICOPTERS**

**New Types.** Recent Helicopters (Nouveaux Hélicoptères), Jean-Abel Lefranc. La Nature, no. 2466, July 9, 1921, pp. 20–25, 9 figs. Describes the Damblanc-Lacoin, Oehmichen, Petroczy-Karman, Lamé and Pescara.

**HOBBING MACHINES**

**Hobbing Worms, New Method of.** Gould & Eberhardt Method of Hobbing Worms. Am. Mach., vol. 55, no. 4, July 28, 1921, pp. 141–142, 3 figs. Worms cut with hob having a broaching action. Short hob permits cutting worms having shoulders at both ends.

**Theory and Practice.** Hobs and Hobbing, T. A. Stoddart. Eng. Prod., vol. 3, no. 44, August 4, 1921, pp. 102–104, 4 figs. Theory and practice of modern machines.

### HOISTS

**Mine.** The Graphical Dynamics of a Winding Engine—III, Charles D. Mottram. Colliery Guardian, vol. 122, no. 3159, July 15, 1921, pp. 170–171, 5 figs. Discusses the question of friction between lubricated surfaces. (To be continued.)

### HOUSES, CONCRETE

**England.** Concrete House Building. Concrete & Constructional Eng., vol. 16, no. 7, July 1921, pp. 425–431, 10 figs. Housing scheme at Southport, England.

### HOWITZERS

**75-mm. Pack.** 75-mm. Pack Howitzer vs. 2.95-inch V. M. Mountain Gun, O. L. Beardsley. Army Ordnance, vol. 2, no. 1, July-August, 1921, pp. 38–44, 11 figs. Table of characteristics.

### HYDRAULIC TURBINES

**Development.** Recent Development of Water Turbines (Die neuere Entwicklung der Wasserturbinen), Dieter Thoma. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 26, June 25, 1921, pp. 679–686, 21 figs. Modern Francis turbines; new types of draft tubes and their influence on motion of water in rotor; limited sphere of present turbine theory; useful scope of Kaplan turbine; the Moody turbine; vertical single-wheel turbines; high-pressure Francis turbines with vertical shaft; transformer installations; success of Bauersfeld's analytical turbine theory.

### HYDROAEROPLANES

**Caproni Giant.** The Caproni Giant Hydroplane (L'hydravion triplan geant Caproni). Le Génie Civil, vol. 79, no. 2, July 9, 1921, pp. 39–40, 5 figs. Particulars of dimensions and tests.

### HYDROELECTRIC PLANTS

**California.** Caribou Power Plant Completed, Charles W. Geiger. Power Plant Eng., vol. 25, no. 14, July 15, 1921, pp. 693–702, 17 figs. Details of power-transmission system, hydraulic equipment, power and efficiency guarantees, etc.

Kern River Plant Number Three of Southern California Edison Company Serves a Dual Purpose. Elec. Rec., vol. 30, no. 1, July 1921, pp. 12–15, 6 figs. Description of concrete dams, generator, and other equipment.

Semi-Automatic Operation Economical in Small Hydro Stations, E. R. Stauffacher & G. Clingwald, Elec. World, vol. 78, no. 5, July 30, 1921, pp. 213–216, 6 figs. Southern California Edison Company plant saves cost of extra equipment in seven months.

**India.** Hydro-Electric Supply in Bombay, India. Managing Engr., vol. 8, no. 3, July 1921, pp. 53–58, 8 figs. Principal features of the Tata Hydro-Electric system. (To be continued.)

**Norway.** The Hydroelectric Plants on Glomfjord in Norway (Die Wasserkraftwerke am Rjukanfos und am Glomfjord in Norwegen), Gg. v. Troeltsch. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 27, July 2, 1921, pp. 707–712, 20 figs. Location of plant on the Glomfjord in the extreme north. Water supply and equalization in lakes, galleries and pipe lines; machine house; cost of installation and price of current; turbines of 25,000 and 27,500 hp. respectively with 442 m. head; double regulation with needle nozzle and deflector.

**Sweden.** Trollhättan Hydroelectric Plant (Installations Hydro-électriques de Trollhättan), A. Tétrel. L'Electricien, vol. 52, no. 1278, June 15, 1921, pp. 265–271, 7 figs. Describes equipment, including d.c. and a.c. apparatus, insulation, etc., also substations.

**Switzerland.** Large Modern Hydroelectric Plants in Switzerland (Grandi Impianti Idroelettrici Moderni in Svizzera), Giovanni Rodio. L'Industria, vol. 35, no. 12, June 30, 1921, pp. 272–277, 17 figs. Detailed description of the Ritom plant, including dams, water supply, Pelton wheels, turbogenerators, transformers. (To be continued.)

The Construction of the Oberhasle Hydroelectric Plants According to the Projects of the Bernese Power Works Corp. (Die Bauten für die Kraftwerke Oberhasle gemäss den Projekten der B.K.W.). Schweizerische Bauzeitung, vol. 78, nos. 1 and 2, July 2 and 9, 1921, pp. 1–6 and 22–24, 15 figs. Account of project developed by G. Narutowics. Notes on water supply and available energy; building installations and transportation arrangements; water storage plants; the power stations Guttannen and Innertkirchen; costs of installation and price of energy.

The Hydroelectric Plant of Fully (Switzerland) [Die Wasserkraftanlage von Fully (Schweiz)], H. Fernau. Zeit. des Oesterr. Ingenieur- u. Architekten-Vereines, vol. 73, no. 24–25, June 24, 1921, pp. 163–166, 5 figs. Describes plant with total head of 1654 m., with special details of a pressure pipe line laid underground without any masonry support or anchorage. Operating experiences since 1914, when plant was completed.

### HYDROGEN

**Commercial Production.** Commercial Production of Hydrogen Gas For Aeronautics (Procédés de Fabrication Industrielle de l'Hydrogène Aerostatique, Capt. Verneuil. L'Aéronautique, vol. 3, no. 25, June 1921, pp. 232–239, 4 figs. A review of existing methods, including the Hembert and Henry and the Badische Anilin.

## I

### IGNITION

**Magnets.** Magnetos for Ignition Purposes in Internal Combustion Engines, E. A. Watson. Jl. Instn. Elec. Engrs., vol. 59, no. 301, May 1921, pp. 445–466, Discussions pp. 467–490, 26 figs. Discusses conditions to be fulfilled by ignition magnetos on internal combustion engines and deals with the principles of operation of a magneto.

### IMPACT TESTING

**Suggestions.** Impact Tests and Allowances, Harry John Fereday. Engineering, vol. 112, no. 2897, July 8, 1921, p. 80. Suggestions for conducting future tests in order to obtain, if possible, new formula for impact effect. Paper read before Instn. Civ. Engrs.

### INDUSTRIAL MANAGEMENT

**Cost Reduction.** Reducing Manufacturing Costs by Studying Power Demand, R. S. Lowry. Elec. Wld., vol. 78, no. 6, August 6, 1921, pp. 257–258. Draws attention to inefficient operating conditions and causes of unnecessary expenditure.

**Efficiency Control.** Controlling Efficiency in the Clay Plant, Arthur H. Kaeppel. Brick & Clay Rec., vol. 59, no. 3, August 9, 1921, pp. 188–191, 3 figs. Discusses factory efficiency reports and production charts.

**Factory Managers.** The Duties of a Modern Factory Manager (Vilka krav höra ställas pa en modern arbetsledare?), Oliof Kärnekull. Teknisk Tidskrift, vol. 51, no. 19, May 14, 1921, pp. 221–226, 3 figs. Duties of a manager with regard to carrying out and standardization of production methods, selection of personnel with aid of psychology, etc. Loss of time in industrial plants is said to average 30 per cent of working time, half of which is unavoidable loss. This, it is claimed, can be considerably reduced by suitable working plans. In one case it was reduced in four months from 70 to 10 per cent.

**Factory Statistics.** Factory Statistics (Betriebsstatistik), Rudolf Reischle. Zeit. des Bayerischen Revisions-Vereins, vol. 25, nos. 10 and 11, May 31 and June 15, 1921, pp. 81–84 and 94–95, 3 figs. Deals with purpose and character, fundamental principles, carrying out and utilization of factory statistics; bookkeeping and net cost accounting; commercial bases for calculation of general operating costs.

**Follow-Up System.** Follow-Up System for the Drawing Office. Machy. (Lond.), vol. 18, no. 457, June 30, 1921, pp. 385–388, 6 figs. System for recording status and daily progress of work during process of manufacture.

**Inspection.** An Inspection and Progress System, E. A. Allcutt. Eng. & Indus. Management, vol. 6, no. 3, July 21, 1921, pp. 58–61 and 64. Explains the three main objects of successful management; good work, rapid work, economical work.

**Instruction Sheets.** Proposals for New Factory Instruction Sheets (Entwürfe neuer Betriebsblätter). Betrieb, vol. 3, no. 19, June 25, 1921, p. 136. Proposal of Works Dept. of German Federation of Technical and Scientific Societies for care and operation of lifting magnets.

Proposals for New Factory Instruction Sheets (Entwürfe neuer Betriebsblätter). Betrieb, vol. 3, no. 17, May 25, 1921, pp. 126–128. Proposal of Works Dept. of German Federation of Technical and Scientific Societies for care of ball bearings; measures for prevention of fire; and care of gear drive.

**Motion Study.** Scientific Management and Motion Study, F. James Butterworth. Royal Engrs. Jl., vol. 34, no. 2, August 1921, pp. 59–70, 7 figs. Discusses the work of Taylor and Gilbreth.

**Output, Measurement of.** The Measure of Output in Engineering, J. E. Powell. Mech. Wld., vol. 70, no. 1803, July 22, 1921, pp. 67. Discusses formulating the measure and responsibilities of management. (Abstract paper read before Inst. Ind. Admin.)

**Overhead Costs.** Cutting Overhead Cost Instead of Wages, Don. F. Kennedy. Iron Age, vol. 108, no. 2, July 14, 1921, pp. 79–81. Large Detroit automobile company paid war-time wages, ran half time and in same period made profits.

**Purchasing System.** What is a Comprehensive Purchasing System? Wilfred G. Asble. Can. Machy., vol. 26, no. 2, July 14, 1921, pp. 27–29, 9 figs. Suggestions for organizing effective system. Illustrations of form cards suitable for purchasing department.

**Small Shop.** Organization and Management of the Small Shop—I, II and III, Elmer W. Leach. Am. Mach., vol. 55, nos. 3, 5 and 7, July 21, Aug. 4 and 18, 1921, pp. 81–84, 190–193 and 262–266. July 21: How one small shop started and won battle against odds. Aug. 4: How to analyze manufacturing and marketing problems. Aug. 18: Methods of market analysis; different ways of reaching ultimate consumer; importance of establishing definite sales policy.

**Storeroom Methods.** Six Ways to Simplify Stockroom Routine, V. C. Kreuter. Factory, vol. 27, no. 2, August 1921, pp. 192–194, 5 figs. Shows how, through changes in stockroom routine, difficulties in routing, production, cost-keeping and inventory work may be adjusted.

**Stores Keeping.** Continuous Stores Keeping Cuts Investment. Iron Age, vol. 108, no. 5, Aug. 4, 1921, pp. 253–254, 2 figs. System checks and almost automatic control of ordering materials economizes in space required and in amount carried.

**Toolroom Organization.** Organization of the Tool Room, G. W. Tripp. Eng. & Indus. Management, vol. 6, no. 1, July 7, 1921, pp. 2–5, 3 figs. Outlines method of organizing tool room. Notes on arrangement of tool store, manufacture of jigs, grouping of cards and planning of work.

[See also TIME STUDY.]

### INDUSTRIAL RELATIONS

**Justice in.** The Way Out in Industrial Relations, John Calder. Iron Age, vol. 107, no. 26, June 30, 1921, pp. 1766–1767. How shall management, labor and public secure justice? What underlies movement for a conference footing in individual companies. (Abstract.) Address before Iowa Mfrs. Assn.

### INTERNAL-COMBUSTION ENGINES

**Cast Iron, Use of.** Cast Iron in the Construction of Internal Combustion Engines. Eng. & Indus. Management, vol. 5, no. 26, June 30, 1921, p. 736. Describes effect of increases of temperature on gray cast iron employed in construction of automobile cylinders and pistons.

**Electric Starters.** Electric Starters for Explosion Engines (Sur l'installation des demarreurs electriques pour moteurs a explosions), M. Digeion. Révue Générale de l'Électricité, vol. 10, no. 3, July 16, 1921, pp. 103–106, 4 figs. Considers conditions necessary, power absorbed, coupling, etc.

**Influence of Fuels.** The Influence of Various Fuels on the Performance of Internal Combustion Engines—VI, H. R. Ricardo. Automobile Engr., vol. 11, no. 152, July 1921, pp. 242–247, 6 figs. Experimental investigation into their behavior.

**Installation.** Practical Notes on the Installation and Running of Petrol, Petrol-Paraffin, and Semi-Diesel Engines, D. P. Lamb. Mech. Wld., vol. 70, no. 1803, July 22, 1921, pp. 72–73. Considers shafting, motor-seating, stern tube, fuel tanks, etc. (To be continued.)

**Large Cylinders.** Internal-Combustion Engines with Large Cylinders, James McKechnie. Engineering, vol. 112, no. 2898, July 15, 1921, pp. 132–134, 5 figs. Includes indicator cards and summaries of some of the trials of engines referred to, and also of Vickers' Narragansett type commercial marine engine with 24 1/2-in. cylinder. Paper read before Instn. Civ. Engrs.

**Types.** The Internal-Combustion Engine. Steamship, vol. 33, no. 386, August 1921, pp. 49–53, 14 figs. Description of the two-stroke-cycle, four-stroke-cycle and semi-Diesel engines.

[See also AEROPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; OIL ENGINES; SEMI-DIESEL ENGINES.]

### IRON

**Corrosion.** A Colloid Theory of the Corrosion and Passivity of Iron, and of the Oxidation of Ferrus Salts, John Albert Newton Friend. Jl. Chem. Soc., vol. 119–120, no. 704, June 1921, pp. 932–949, 2 figs. Author directs attention to a few important observations which cannot be explained by any known theory, and suggests new theory which appears to account for facts in reasonable manner.

A New Theory of the Corrosion of Iron, J. Newton Friend. Am. Electrochemical Soc. 40th Gen. Meeting 1921, advance paper, June 4, 1921, 13 pp., 9 figs. Writer puts forward auto-colloidal catalytic theory which postulates corrosion as starting by formation of colloidal ferrous hydroxide, which latter is alternately reduced by contact with iron and oxidized by contact with air, thus continuing corrosion and production of rust.

Corrosion of Iron and Its Prevention by Degassing Feedwater (Les Corrosions du Fer et Leur Suppression Par le Dégazage de l'Eau), G. Paris. Chimi & Industrie, vol. 6, no. 1, July 1921, pp. 11–32, 33 figs. Discusses theories of corrosion, effect of bodies dissolved in water, action of electric current, degasification and apparatus used.

**Electrodeposition.** Researches on the Electrodeposition of Iron, W. E. Hughes. Am. Electrochemical Soc. 40th Gen. Meeting 1921, advance paper, Apr. 25, 1921, pp. 15–33. Notes on electrodeposition of iron from sulphate, chloride, and sulphate-chloride solutions, stating results obtained by different workers. Writer also discusses various researches upon other solutions, with his own experiences and comments.

### IRON AND STEEL

**Canada.** The Present Status and Future Possibilities of the Iron and Steel Industry in Canada, J. F. K. Brown. Iron & Steel of Can., vol. 4, no. 6, July 1921, pp. 159–166. Review of fundamental conditions of existence and growth of iron and steel manufacture, and discussion of advisability of capital investment in iron and steel enterprises in Canada.

**England.** Conditions in the Iron and Steel Industry. Engineer, vol. 131, no. 3417, June 24, 1921, pp. 675–676. Memorandum drawn up by British National Federation of Iron and Steel Manufacturers, representing employers, and Iron and Steel Trades Confederation, representing workmen.

**Production on Pacific Coast.** Factors in the Production of Iron and Steel on the Pacific Coast, Clyde E. Williams. Min. & Sci. Press, vol. 123, no. 3, July 16, 1921, pp. 94–96, 1 fig. Problem as to whether cheaper iron and steel can be obtained by producing them on Pacific Coast is said to depend upon a number of factors, chief among which are supply of raw material, amount and nature of market, and size and type of smelting operation. Paper presented at Int. Min. Convention, Oregon.

**Protective Coatings.** The Relative Values of Protective Metallic Coatings for Iron and Steel, Sherrard O. Cowper-Coles. Engineering, vol. 112, no. 2899, July 22, 1921, p. 167. Relative advantages and disadvantages of zinc coatings. Discusses four methods in which it can be applied, namely dipping in molten zinc, sherardizing, electro-zincing and spraying. Paper read before Instn. Civ. Engrs.

### IRON CASTINGS

**Loam Process.** British Shop Casts Big Ingot Mold. Foundry, vol. 49, no. 14, July 15, 1921, pp. 565–566,

1 fig. Loam process employed in making $87^1/_2$-ton casting in Sheffield district. Casting annealed for two weeks. Special arrangements made for shipment 60 miles by rail.

**Reversed Chilled.** Reversed Chilling of Castings (Der umgekehrte Hartguss), P. Bardenheuer. Stahl u. Eisen, vol. 41, nos. 17 and 21, Apr. 28 and May 26, 1921, pp. 569–575 and 719–723, 32 figs. As results of investigation, the nature and origin of this phenomenon is explained. Outer zone of white congealed iron due to overcooling becomes gray through subsequent formation of graphite. Overcooling is due to a high sulphur content and a low casting temperature. Photomicrographs.

**IRON FOUNDING**

**Centrifugal Casting.** Chill Casting and Centrifugal Casting (La Coulée en Coquille et par Centrifugation) La Fonderie Moderne, no. 4, April 1921, pp. 87–89. Discusses operation of both methods.

**IRON, PIG**

**Dephosphorizing.** The Dephosphorizing of the Ilsed Basic Pig Iron in Converter and Open-Hearth Furnace (Die Entphosphorung des Ilseder Thomasroheisens im Konverter und im Martinofen), Arthur Jung. Stahl u. Eisen, vol. 41, no. 20, May 19, 1921, pp. 687–692. Describes dephosphorizing in open-hearth furnace of pig iron with 3 per cent phosphorus content and utilization of the phosphoric acid, with use of a poor and a rich ore in preliminary melting. Results are compared with basic process, which is said to insure a better utilization of phosphorus in pig iron.

**Synthetic.** Synthetic Production of Foundry Pig Iron and Its Properties (Synthetische Herstellung von Giessereiroheisen und dessen Eigenschaften), J. Bronn. Stahl u. Eisen, vol. 41, no. 26, June 30, 1921, pp. 881–888, 13 figs. Physical and chemical results of comparative tests of Rombach special process iron and Swedish charcoal pig iron show former to be of equal value, and its more frequent use is recommended.

# J

**JIGS**

**Design and Use.** Jigs for Intensive Production. Eng. Production, vol. 3, no. 40, July 7, 1921, pp. 8–12, 14 figs. Observations on design and use of typical examples.

# K

**KEROSENE**

**Carburation of.** Present State of Carburation of Kerosene (État Actual de la Carburation au Pétrole Lampant), Drosne. Société des Ingénieurs Civils de France, vol. 74, nos. 1, 2, 3, January-March 1921, pp. 35–52, 3 figs. Describes the Le Grain type of carburetor, fulfilling practically all required conditions.

# L

**LATHE TOOLS**

**Precision-Lathes.** Tools Used in Making of Precision Lathe, Robert Mawson. Can. Machy., vol. 26, no. 1, July 7, 1921, pp. 68–69 and 74, 9 figs. Notes on different operations.

**Ring Tools.** The Ring Tool. Engineering, vol. 112, no. 2898, July 15, 1921, pp. 95–96, 5 figs. Article is said to complete geometry of ring tool and will be found useful for reference in drawing offices using these tools extensively.

**LATHES**

**Manufacture.** Making Flather Lathe Parts Interchangeable. Am. Mach., vol. 55, no. 2, July 14, 1921, pp. 50–53, 21 figs. Each part a separate unit. Jigs and fixtures eliminate individual fitting. All parts made to gages.

**Turret.** Obtaining Production on the Vertical Turret Lathe. Machy. (Lond.), vol. 18, no. 459, July 14, 1921, pp. 447–453, 18 figs. Application of vertical boring and turning mill to machine shop practice, including typical examples and description of tooling used.

Tooling in the Modern Turret Lathe. Eng. Production, vol. 3, nos. 42 and 43, July 21 and 28, 1921, pp. 61–66, 18 figs. and 83–89, 19 figs. Methods and fixtures for economical production.

**LIGHTING**

**Charts and Data.** Charts and Data for Industrial Lighting Designs, P. A. Powers. Elec. Rev., vol. 79, no. 7, August 13, 1921, pp. 231–234, 4 figs. Height of suspension related to spacing, reflector and lamp.

**Illuminating Engineering.** Illuminating Engineering, J. H. Asdell. Beama, vol. 9, no. 1, July 1921, pp. 25–29. Future field.

**Office Buildings.** High-Intensity Illumination of Office Buildings, Ivan M. Kirlin. Elec. Rev. (Chicago), vol. 79, no. 7, August 13, 1921, pp. 235–238, 7 figs. Equipment employed and results obtained in lighting new offices of the Detroit Edison Co.

**Railway Buildings.** Electric Lighting of Railway Buildings, J. H. Kurlander. Ry. Elec. Engr., vol. 12, no. 7, July 1921, pp. 273–277, 11 figs. Three fundamental considerations of successful lighting installation are said to be intensity, quality and distribution. Recommendations.

**LOCK WASHERS**

**Standards for.** Current Standardization Work. Jl. Soc. Automotive Engrs., vol. 9, no. 2, August 1921, pp. 118. Gives proposed dimensions of lock washers.

**LOCOMOTIVE BOILERS**

**Repairing Cracks in Tubeplates.** Repairing Cracks in the Copper Tubeplates of Locomotive Boilers, A. Wrench. Engineering, vol. 112, no. 2902, Aug. 12, 1921, pp. 251–252, 11 figs. Discusses methods of repairing.

**Steel vs. Brass Tubes.** Steel or Brass Boiler Tubes For Locomotives (Le Tube de Chaudiere de Locomotive acier ou Laiton?), O. Hock. Revue Universelle des Mines, vol. 10, no. 2, Series 6, July 15, 1921, pp. 117–128. Discusses the influence of the war and price of metals, life of steel tubes, etc. (To be continued.)

**LOCOMOTIVES**

**Air-Operated Auxiliaries.** Maintenance of Air Operated Auxiliaries. Ry. Mech. Engr., vol. 95, no. 8, August 1921, pp. 484–487, 5 figs. Discusses saving effected by the application of Air Brake Association condemning limits.

**Booster Tests.** Locomotive Booster Tests on Timiskaming & Northern Ontario Railway. Can. Ry. & Mar. World, no. 280, July 1921, pp. 356–357, 4 figs. Results of tests conducted with Can. Nat. Rys. dynamometer car 84.

**British.** Great Central Railway Four-Cylinder Engines—III. Supp. 3. Engineer, vol. 131, no. 3417, June 24, 1921, pp. 660–661, 5 figs. Characteristics: Type, 4-6-0; driving effort, 29,500 pounds; diameter of driving wheels, 5 ft. 8 in.

Heavy Locomotive Work on the Great Northern Railway (England). Ry. Gaz., vol. 35, no. 1, July 1, 1921, pp. 11–14, 3 figs. Passenger trains with 18 to 20 coaches and weighing from 590 to 650 tons are daily hauled between Doncaster and London by one engine of No. 1000 class. Discusses performance of locomotives on recent typical run.

**Consolidation.** High Capacity Consolidation Type Locomotives. Ry. Rev., vol. 69, no. 7, August 13, 1921, pp. 197–205, 13 figs. Discusses design and equipment, fuel consumption, fuel and tonnage performance, etc. Tractive effort, 68,200 lb.

**Cut-off Control.** The Automatic Control of Locomotive Cut-off, E. S. Pearce. Ry. Mech. Engr., vol. 95, no. 8, August 1921, pp. 488–493, 13 figs. Utilizing back pressure as actuating force.

**Engine Design.** Modern Locomotive Engine Design and Construction—LXXII. Ry. Engr., vol. 42, no. 498, July 1921, pp. 255–258, 2 figs. Considerations and factors determining most suitable cross section for locomotive connecting rods.

**4-8-0.** Recent Designs of Twelve-Wheel Locomotives. Ry. Age, vol. 71, no. 6, August 6, 1921, pp. 251–252, 4 figs. Description of various 4–8–0 types.

**4-6-2 vs. 2-10-2.** Heavy Locomotives for the Southern Pacific. Ry. Mech. Engr., vol. 95, no. 8, August 1921, pp. 481–483, 5 figs. Comparison between the 4-6-2 and 2-10-2 types. Tractive efforts are 43,660 and 75,150 lb., respectively.

**Malay States Railways.** Locomotives for Federated Malay States Railways. Ry. Age, vol. 71, no. 3, July 16, 1921, pp. 119–120, 3 figs. Locomotives manufactured by Baldwin Locomotive Works are of most up-to-date type and have open bar steel frames. Weight and dimensions are tabulated.

**Mechanical Efficiency.** Locomotive Resistance and Mechanical Efficiency, Kiichi Asakura. Ry. Age, vol. 71, no. 5, July 30, 1921, pp. 211–216, 9 figs. Establishes a formula for calculating mechanical efficiency.

**Mikado.** Heavier Mikado Type Locomotives Cut Operating Cost. Ry. Rev., vol. 69, no. 3, July 16, 1921, pp. 83–85, 3 figs. Improved type used on Baltimore & Ohio railroad handle 5800 tons over 0.3 per cent grade and are said to be more economical on account of ability to use mine-run coal.

**Oil-Burning.** Oil-Burning Locomotives in India and Mesopotamia, A. M. Bell. Ry. Engr., vol. 42, no. 498, July 1921, pp. 247–250, 6 figs. Information with regard to utilization of oil fuel for locomotives in the East.

Oil-Burning Locomotives on the Great Eastern Railway (England). Ry. Gaz., vol. 35, no. 1, July 1, 1921, pp. 9–10, 3 figs. Describes how G.E.R. locomotives are being fitted up for oil-fuel burning on the Holden system.

**Shops, England.** Methods Employed in the Locomotive Shops of the Great Western Railway Co., Swindon—IV. Machy. (Lond.), vol. 18, no. 458, July 7, 1921, pp. 405–407. Details of heat-treating plant and machining operations on various components of brake gear and link motion.

**Southern Pacific Lines.** New Pacific, Santa Fe and Switching Locomotives for the Southern Pacific Lines. Ry. & Locomotive Eng., vol. 34, no. 7, July 1921, pp. 199–200, 3 figs. Marked increase in weight and tractive power.

**Superheaters.** The Application of Superheaters to Light Locomotives. Ry. & Locomotive Eng., vol. 34, no. 7, July 1921, pp. 188–189, 5 figs. Examples of recent construction in which installations have been made.

**Tank.** Heavy Tank Locomotives on the London & South Western Railway. Ry. Gaz., vol. 35, no. 1, July 1, 1921, pp. 16 and 22, 2 figs. New 4-8-0 side tank locomotive built for work at Feltham concentration yard and for transfer service between Nine Elms and Feltham.

**Tire-Fixing Appliance.** A New Machine for Railway Work. Eng. Production, vol. 2, no. 39, June 30, 1921, p. 772, 1 fig. Appliance for use in connection with tire fixing.

**LOOMS**

**Roller Bearings on.** Roller Bearings on Looms. Textile World, vol. 60, no. 6, August 6, 1921, pp. 89–91, 2 figs. Shows a power saving of 23 per cent.

**LUBRICATING OILS**

**Carbonization in Internal-Combustion Engines.** The Carbonization of Lubricating Oils in Internal-Combustion Engines, Frederic H. Garner. Jl. Instn. Petroleum Technologists, vol. 7, no. 26, Apr. 1921, pp. 98–126 and (discussion and bibliography) pp. 126–148, 8 figs. Method of determining asphaltic resins in lubricating oils was devised by utilizing the selective absorbent power of animal charcoal. Results of experimental work on evaporation and carbonization of series of lubricating oils derived from Texas and Pennsylvania crudes.

**Castor Oil.** Castor Beans and Castor Oil, M. Rindl. So. African Jl. Ind., vol. 4, no. 6, July 1921, pp. 540–547. Discusses cultivation of the bean and use of castor oil as a lubricant.

**Reclaimed.** The Reclamation of Used Motor Oils, William F. Parish. Sci. Lubrication, vol. 1, no. 6, June 1921, pp. 5–7. Discusses the value of reclaimed oil and advocates its salvage.

**Viscosity-Temperature Chart.** A New Chart for Viscosity Temperature Relations. Lubrication, vol. 7, no. 6, June 1921, pp. 5–8, 2 figs. Presents chart, one of important features of which is that every known lubrication oil can be shown comparatively.

**LUBRICATION**

**Steam-Cylinder.** Steam cylinder Lubrication. Lubrication, vol. 7, no. 6, June 1921, pp. 1–4 and 9–13. Notes on what the oil must lubricate; how it can best be applied; conditions under which it must operate; selection of oils; and how to tell if lubrication is correct.

# M

**MACHINE GUNS**

**Dispersion.** Long Range Small Arms Firing—IV, Glenn P. Wilhelm. Army Ordnance, vol. 2, no. 1, July-August 1921, pp. 31–35, 4 figs. Discusses dispersion, especially kinds of machine-gun dispersion.

**Synchronizing with Airplane Propeller.** Engineering Field of Aeronautics—XI, T. L. Sherman. Commonwealth Engr., vol. 8, no. 11, June 1, 1921, pp. 322–325, 3 figs. Discusses wave transmission as applied to secure synchronism of a machine gun with the propeller of an aeroplane engine.

**MACHINE SHOPS**

**High- and Low-Bay Type.** The High- and Low-Bay Type of Machine Shop, Fred H. Colvin. Am. Mach. vol. 55, no. 3, July 21, 1921, pp. 91–93, 7 figs. Wide, high bays, with low bays between, give light from both sides. Standard columns and shapes make rearrangement easy at any time.

**MACHINERY**

**Foundation Bolts.** Elements of Design for Foundation Bolts of Machines, Terrell Croft. Coal Age, vol. 20, nos. 2 and 3, July 14 and 21, 1921, pp. 45–51, 9 figs., and 95–99, 13 figs. Summary of available information concerning design of machinery foundations and holding-down bolts necessary. Devices to increase holding power of anchor bolts; relative value of neat cement, sulphur and lead.

**MALLEABLE IRON**

**Structure.** Explain the Structures of Malleable, W. R. Bean, W. H. Highriter and E. S. Davenport. Foundry, vol. 49, no. 14, July 15, 1921, pp. 557–564, 40 figs. Microscope reveals causes of many different effects found in fracture of malleable cast iron. Condition of carbon is said to be largely governed by composition and by anneal. Paper presented before Am. Foundrymen's Assn.

**Sulphur in.** Sulphur in Malleable Cast Iron, Lester C. Crome. Chem. & Met. Eng., vol. 25, no. 6, August 10, 1921, pp. 247–248. Discusses determination of sulphur in white cast iron by the evolution process.

**MARINE STEAM TURBINES**

**Gearing.** Marine Steam-Turbine Gearing, J. Hamilton Gibson. Trans. Inst. Mar. Engrs., session 1921–22, June 1921, pp. 115–126 and 127–143, 1 fig. on p. 144. Deals with essential elements of manufacture, erection and running.

**MATERIALS**

**Storage.** Principles of Storage. Iron Age, vol. 108, no. 4, July 28, 1921, pp. 194–196, 8 figs. Experience and practices of Pittsburgh railways summarized.

**METAL SPRAYING**

**Schoop Process.** Progress in Metal Coating, Schoop Process of Spraying Metals or Alloys (Les Progrès de la Métallisation, Procédé Schoop Par Pulverisation de Metaux ou Alliages Fondus), P. Nicolardot. Chimie & Industrie, vol. 5, no. 6, June 1921, pp. 619–635, 26 figs. Describes the Schoop process, apparatus and applications in industry.

**METALLOGRAPHY**

**Foundry Uses.** Use of Metallography in Metal Foundries (Anwendungen der Metallographie in der Metallgiesserei), Rudolf Stotz. Giesserei-Zeitung, vol. 18, nos. 13 and 14, July 5 and 12, 1921, pp. 207–211 and 215–220, 32 figs. Discusses internal structure of metals and alloys in relation to foundry practice. Address delivered before Assn. German Metal Foundrymen.

**METALS**

**Annular Cracks.** Annular Cracks, R. R. Clarke. Metal Industry (Lond.), vol. 19, no. 2, July 8, 1921, pp. 27–28, 2 figs. Discusses various theories for their formation.

**Calorizing.** Calorizing as a Protection for Metals, A. V. Farr. Forging & Heat-Treating, vol. 7, no. 7, July 1921, pp. 384–386, 4 figs. Also in Blast Furnace and Steel Plant, vol. 9, no. 7, July 1921, pp. 431–433. Recent developments. Characteristics of a good protective coat. Materials that can be calorized. Cost and various applications. (Abstract.) Paper read before Eng. Soc. West. Pa.

Protecting Metals by Calorizing (Les Méthodes de Protection des Métaux et la Calorisation), Léon Guillet. Revue de Métallurgie, vol. 18, no. 5, May 1921, pp. 283–289, 6 figs. Describes the three methods depending on (1) reaction of the metal itself, (2) adding another metal, and (3) non-metallic coating.

**Properties at High Temperatures.** Study of the Physical Properties of Metals at High Temperature. (Studio delle Proprieta Fisiche dei Metalli Alle Elevate Temperature Precedenti il Loro Intervallo di Plasticita). Il Forno Elettrico, vol. 3, no. 5, May 15, 1921, pp. 71–73. Particulars of experiments carried out and conclusions.

**Scratches, Effect of.** The Effects of Scratches in Materials, Ernest George Coker. Engineering, vol. 112, no. 2897, July 8, 1921, pp. 81–82. Effect of different kinds of scratches on stressed materials. Paper read before Instn. Civ. Engrs.

**Viscosity.** On the Determination of the Coefficient of Normal Viscosity of Metals, Kôtarô Honda and Seibei Konno. Lond., Edinburgh, & Dublin Philosophical Mag., vol. 42, no. 247, July 1921, pp. 115–123, 3 figs. Coefficients of twelve different metals are measured at room temperature, values ranging from $0.7 \times 10^{8}$ to $27 \times 10^{8}$. Annealing causes diminution of coefficient of viscosity; in carbon steels coefficient increases with content of carbon.

**MICROMETERS**

**Screw.** The Spreading of Micrometer Frames (Die Aufbiegung von Schraubenmikrometern), G. Berndt. Betrieb, vol. 3, no. 19, June 25, 1921, pp. 574–581, 12 figs. Results of experiments with a number of screw micrometers by different firms. A formula for calculation of semi-circular frames is developed. A table of permissible amounts of spreading of frames is presented and weights for rectangular cross-section frames are calculated.

**MILLING MACHINES**

**Continuous.** New 18-Inch Continuous Mill. Blast Furnace and Steel Plant, vol. 9, no. 7, July 1921, pp. 430–431, 4 figs. Recently completed by Whitaker-Glessner Co. at Portsmouth, Ohio. Consists of six stands of 18-in. roughing and finishing rolls together with two edging mills, located respectively in front of first and third roughing passes.

Whitaker-Glessner Continuous Mill. Iron Age, vol. 107, no. 26, June 30, 1921, pp. 1747–1749, 4 figs. For making sheet bars or billets. Includes edging rolls. Approach table with skewed V-groove rollers for centering blooms.

**Universal.** A New Universal Milling Machine. Eng. Production, vol. 3, no. 40, July 7, 1921, pp. 18–19, 2 figs. Details of latest motor-driven universal milling machine manufactured by J. Perkinson & Son, Shipley, England.

**MOLDING MACHINES**

**Centrifugal.** Centrifugal Molding Machine of E. O. Beardsley and W. F. Piper (Die Schleuderformmaschine von E. O. Beardsley and W. F. Piper. Stahl u. Eisen, vol. 41, no. 21, May 26, 1921, pp. 723–724, 1 fig. Refers to centrifugal molding machines described in same journal (Sept. 30, 1920) which are now being manufactured by the inventors in several forms, the most popular being the portable machine. Recent improvement.

**French Practice.** Mechanical Molding Practice (La Pratique de Moulage Mécanique), G. Pouplin. La Fonderie Moderne, no. 5, May 1921, pp. 128–137, 6 figs. Discusses various methods for molding grate bar and aluminum casings for motor cars.

**Operation.** Machine Molding (La Pratique de Moulage Mécanique). G. Pouplin. La Fonderie Moderne, no. 4, April 1921, pp. 92–102, 7 figs. Describes the operations in detail. (To be continued.)

**MOLDING METHODS**

**Follow-Board Use.** Accentuates Use of Follow Board Pat. Dwyer. Foundry, vol. 49, no. 15, August 1, 1921, pp. 585–590, 11 figs. Match plates extensively used in new foundry equipment.

**Gating.** Elevated, Midway, and Subway Gating, William H. Parry. Am. Mach., vol. 55, no. 6, Aug. 11, 1921, pp. 209–210, 8 figs. Using three-part flasks on two-part work to increase production. Arrangement of gates and runners. Abandoning horn gate.

**Pipe Fittings.** Large Elbow Made in Dry Sand Mold, James J. Zimmerman. Foundry, vol. 49, no. 15, August 1, 1921, pp. 607–610, 8 figs. Methods employed in the production of pipe fittings for 96-in. diameter exhaust line.

**Sash Weights.** How to Make Sash Weight Castings, J. H. Anderson. Foundry, vol. 49, no. 15, August 1, 1921, pp. 592–594, 5 figs. Shows how these castings can be produced rapidly and economically.

**MOLYBDENUM STEEL**

**Motor Cars.** Molybdenum Steel in the Motor Car. Sci. Am., vol. 125, no. 4, July 23, 1921, pp. 62–63, 4 figs. Notes on reducing weight in high-power cars by use of new steel alloys.

**Physical Properties.** The Value of Molybdenum Alloy Steels, G. W. Sargent. Trans. Am. Soc. Steel Treating, vol. 1, no. 10, July 1921, pp. 589–596 and (discussion) pp. 596–597, 5 figs. Notes on manufacture and physical properties.

**MONEL METAL**

**Magnetic Properties.** Monel Metal Has Definite Magnetic Properties, Charles W. Burrows. Elec. World, vol. 78, no. 3, July 16, 1921, pp. 115–116, 3 figs. Investigation shows magnetic characteristics considerably less than iron. Important property in loss of magnetism at temperature near 200 deg. fahr.

**MOTOR-TRUCK TRANSPORTATION**

**Chicago.** Motor Truck Haulage in Chicago. Elec. Ry. Jl., vol. 58, no. 4, July 23, 1921, pp. 133–135, 4 figs. North Shore line has receiving station close to Chicago Loop and hauls merchandise on trucks to rail terminal. Study shows service to be costly taken by itself, but valuable as business producer.

**Development and Future.** The Development and Future of Handling Freight by Motor Trucks. Jl. Engrs.' Club of Phila., vol. 38–6, no. 198, June 1921, pp. 225–240. Better Highways and Motor Transportation as an Aid to Production, F. W. Fenn. The Motor Truck and Legislation, R. A. Hauer. Motor Truck Operation in Southern Maryland, M. O. Eldridge. Discussions.

**MOTOR TRUCKS**

**Cushioning in.** Cushioning in Motor-Truck Design, Charles O. Guernsey. Jl. Soc. Automotive Engrs., vol. 9, no. 2, August 1921, pp. 143–147 and discussion pp. 147–150, 10 figs. Considers chassis stresses, cushion tires and wheels and elimination of vibration.

**MUSKETS**

**Sights.** Telescopic Musket Sights, H. K. Rutherford. Army Ordnance, vol. 2, no. 1, July-August 1921, pp. 23–30, 17 figs. Discusses ten different kinds of sights.

# N

**NICKEL STEEL**

**Deoxidizing.** Method of Deoxidizing High-Nickel Steel, C. B. Callomon. Foundry, vol. 49, no. 15, August 1, 1921, pp. 590–591. Advocates use of pure manganese instead of aluminum.

# O

**OFFICE MANAGEMENT**

**Data Filing.** Packard's Motor Transport Data Files, Dorsey W. Hyde, Jr. Filing & Office Management, vol. 6, no. 3, August 1921, pp. 71–73. Gives details of classification.

**Government Departments.** Office Management as Applied to Government Establishments, W. E. Mickey. Filing & Office Management, vol. 6, no. 3, August 1921, pp. 65–67, 2 figs. Outline of the work of the various departments.

**OIL ENGINES**

**Crossley Solid-Injection.** The Production of Power from Internal-combustion Engines, F. W. Burstall. Elecn., vol. 86, no. 2249, June 24, 1921, pp. 781–783, 2 figs. Details of the Crossley solid-injection heavy-oil engine of high-compression type, in which the charge is ignited by mixture itself at end of compression.

**French.** A New French Heavy Oil Engine, M. R. E. Mathot. Gas & Oil Power, vol. 16, no. 190, July 7, 1921, pp. 149–150, 1 fig. Describes new type built by Weyher & Richemond, Pantin, near Paris.

**Marine.** Some Observations on Marine Oil Engines, D. M. Shannon. Trans. Inst. Mar. Engrs., session 1921–22, June 1921, pp. 145–164 and (discussion) pp. 165–174, 15 figs. Deals with various types, including Diesel and hot-bulb engines. Diagrams from various types of piston engines.

**OIL FUEL**

**Eyre System.** Eyre System of Liquid Fuel Burning. Tramway & Ry. Wld., vol. 50, no. 3, July 14, 1921, pp. 9–11, 8 figs. This system is extremely simple and suitable for all kinds of furnace work and steam-raising purposes.

**Mexican.** The Production and Combustion of Mexican Fuel Oil—IV. J. M. Pettingell and J. R. Carlson. Combustion, vol. 5, no. 2, Aug. 1921, pp. 66–69, 5 figs. Fuel oil and coal comparison.

**Production.** Fuel Oil, W. A. Whyte. Steamship, vol. 33, no. 385, July 1921, pp. 6–12. Notes on origin, finding and refining of petroleum; statistics of output. Fire precautions and appliances for use on ships burning oils. Paper read before North-East Board of Engrs. & Shipbuilders.

**OIL WELLS**

**Cementing.** The Cementing of Oil Wells. Petroleum Times, vol. 6, no. 130, July 2, 1921, pp. 13–14, 1 fig. Details of the Halliburton cementing process.

**Drilling.** Drilling Oil Wells With the Diamond Drill, Frank A. Edson. Bul. Am. Assn. Petroleum Geol., vol. 5, no. 3, May-June 1921, pp. 386–393. Maintains that the diamond drill affords a means of obtaining much more accurate information and at no greater cost.

Study on Drilling and Behavior of Neighboring Wells, A. W. Ambrose. Oil Field Eng., vol. 23, no. 7, July 1921, pp. 86–88. (From U. S. Bur. of Mines, Bul. 195). Advocates the exchange of information, speaks of the necessity for testing drilling well and testing samples of information for oil.

**Mud Injection.** Introducing Mud-Laden Fluid Under High Pressures Into Porous Formations, H. J. Steiny. Eng. & Min. Jl., vol. 112, no. 5, July 30, 1921, pp. 182, 1 fig.

**OILS**

**Animal, Hydrogenation of.** Hydrogenation of Some Marine Animal Oils (Hydrogénation de quelques huiles d'animaux marins), H. Marcelet. Académie des Sciences, vol. 173, no. 2, July 11, 1921, pp. 104–107. Shows favorable results from experiments carried out.

**Linseed.** Improved Process of Refining Linseed Oil, Alexander Schwarcman. Chem. Age (N. Y.), vol. 29, no. 7, July 1921, pp. 280–282. Writer describes process developed by him and mechanical equipment required therefor.

**Vegetable.** Solvent Extraction in the Vegetable Oil Industry, J. H. Shrader. Chem. & Metallurgical Eng., vol. 25, no. 3, July 20, 1921, pp. 94–100, 6 figs. Stationary and rotary types of extractors; principal solvents; economic considerations; uses of products obtained.

**OPEN-HEARTH FURNACES**

**Egler Blow-Torch Port.** The Egler Blow-Torch Port for Open-Hearth Furnaces. Iron & Coal Trades Rev., vol. 102, no. 2782, June 24, 1921, pp. 846–847, 2 figs. Details of Egler furnace said to be equally adapted to all kinds of gas or liquid fuel and to powdered coal.

**Improvements.** Improvement in Open-Hearth Details, A. G. and A. F. Schumann. Iron Age, vol. 108, no. 5, Aug. 4, 1921, pp. 269–272, 8 figs. New arrangement of reversing furnace valves promotes economy. Burners for liquid fuel and tar. Results in operation.

**Relation of Temperature to Output.** Discussion on Open Hearth Practice, Henry Wm. Seldon. Blast Furnace and Steel Plant, vol. 9, no. 7, July 1921, pp. 422–423. Facts to be considered in relation to open-hearth furnace temperature to furnace output.

**OXY-ACETYLENE WELDING**

**Refrigerating Apparatus.** Oxy-Acetylene Welding of Refrigerating Apparatus, Fred E. Rogers. A.S.R.E. Jl., vol. 7, no. 6, May 1921, pp. 432–450 and (discussion) pp. 450–451, 27 figs. Discusses the importance of true forms, manipulation of torch and welding rod, reinforcement of welds, size of welding rods and tips, etc.

# P

**PARACHUTES**

**Types.** Saving Life in Air Wrecks, T. Orde Lees. Aeronautical Jl., vol. 25, no. 127, July 1921, pp. 317–328 and (discussion) pp. 328–332. Discusses saving of passengers and crew by parachute. Different types of parachutes are described.

**PEAT**

**Pulverized.** Pulverized Peat Fuel a Success, C. L. Bohannan. Jl. Am. Peat Soc., vol. 14, no. 3, July 1921, pp. 19–25. It is claimed that use of pulverized fuel produces a great saving in both fuel and labor costs.

**Russian Plants.** Russian Machine-Cut Peat Plants (Russische Maschinentorfanlagen), A. Naumann. Fördertechnik u. Frachtverkehr, vol. 14, no. 4, Feb. 18, 1921, pp. 50–51. It is claimed that the Russian machine-cut peat plants are the most perfect of their kind in existence.

**PIPE, CAST-IRON**

**Explosion.** Explosion of a Cast-Iron Steel Pipe Engineering, vol. 112, no. 2898, July 15, 1921, p. 102. Results of investigation shows that explosion was due to improper overhauling of drain trap.

**PIPE FITTINGS**

**Casting.** Casting Large Pipe Fittings, James J. Zimmerman. Blast Furnace and Steel Plant, vol. 9, no. 7, July 1921, pp. 417–420, 9 figs. Scott Foundry, Reading, Pa., makes 96-in. elbows for 10,000-kw. installation for steel plant, in dry sand mold. Describes methods.

**PIPE, WOOD-STAVE**

**Use of.** Construction of Wood Pipe Lines (Der Bau hölzerner Rohrleitungen), Leopold Nosseck. Zeit. des Oesterr. Ingenieur- u. Architekten-Vereines, vol. 73, nos. 1–2 and 24–25, Jan. 14 and June 24, 1921, pp. 13–14 and 166–168, 5 figs. Summary of conditions favorable to use of and advantages of wood-stave pipe.

**PISTONS**

**Machining.** Machining Motor Pistons. Machy. (Lond.), vol. 18, no. 458, July 7, 1921, pp. 428–429, 3 figs. Successive steps and equipment employed in machining pistons for high-grade motor car.

**PLANERS**

**Crank-Driven.** Results Obtained with Crank-driven Planers. Machy. (Lond.), vol. 18, no. 458, July 7, 1921, pp. 415–419, 9 figs. Methods of operating machines possessing features of both planer and shaper.

**PLATES**

**Reinforced-Concrete.** Load Listribution in Reinforced-Concrete Plates Supported on Both Sides and under Concentrated Load Lastverteilung bei zweiseitig aufliegenden Eisenbetonplatten mit konzentrierter Belastung), W. Petry. Beton u. Eisen, vol. 20, no. 4–5, Mar. 7, 1921, pp. 60–62. Results of tests carried out by German Committee for Reinforced Concrete in the material-testing station of the Stuttgart Technical Academy.

**POWER PLANTS**

**Dundee, Scotland.** Power Supply in Dundee. Elecn., vol. 87, no. 2252, July 15, 1921, pp. 70–76, 8 figs. Account of progress. Notes on supply conditions, coal and ash handling, boiler house, flues and economizers, feed pumps, generating plant, generators, switchgear, sub-stations, transmissions and distribution.

**Generating Costs.** Generating Costs in Stations of Medium Size, M. J. Idail. Elec. World, vol. 78, no. 4, July 23, 1921, pp. 169–170. Southern station burning Mexican fuel oil averages $1.37 cents per kw-hr.; another station with river washery coal averages $1.24.

**Glasgow, Scotland.** Dalmarnock Power Station, R. B. Mitchell. Elec. Ry. & Tramway Jl., vol. 44, no. 10, June 10, 1921, pp. 261–271, 26 figs. Describes Glasgow plant completed in 1920. Summary of important data concerning boilers, turbo-alternators condensing plant, motors driving auxiliaries, alternators, step-up transformers, switchgear, and other equipment.

**POWER TRANSMISSION**

**Types of Drive.** Progress and Problems of the Mechanical Transformation of Energy (Fortschritte und Probleme der mechanischen Energieumformung) K. Kutzbach. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 26, June 25, 1921, pp. 673–678, 21 figs. Deals with high-speed toothed-gear drive for ship turbines, stationary turbines, electric locomotives and hydroelectric plants; and gives examples of belt and rope drives, typical for trend of recent development.

**PRESSES**

**Design.** Designing Power Press Frames. Eng. Prod., vol. 3, no. 43, July 28, 1921, pp. 76–78, 2 figs. Data for use in determining the leading dimensions.

**PULVERIZED COAL**

**Foundries.** Powdered Coal Applied in Foundry, A. J. Grindle. Foundry, vol. 49, no. 15, August 1, 1921, pp. 617–618. Layout and operation of a powdered-coal installation.

**German Steel Industry.** Powdered Coal as Fuel for Boilers, F. Schulte. Blast Furnace and Steel Plant, vol. 9, no. 7, July 1921, pp. 447–452, 4 figs. Application in German steel industry. Translated from Glückauf, Apr. 30, 1921.

**Properties.** Powdered Fuel, Robert James. Proc. South Wales Inst. Engrs., vol. 37, no. 3, July 7, 1921, pp. 221–236. Continuation of the discussion of Robert James' paper.

**Steam Generation.** Pulverized Firing in Steam Generation, F. J. Crolius. Blast Furnace and Steel Plant, vol. 9, no. 7, July 1921, pp. 453–460. Discusses use of pulverized coal. Typical layout of successfully operated plant.

**Steel Works.** The Adaptability of Pulverized Coal Furnaces for Iron and Steel Works (Anwendbarkeit der Kohlenstaubfeuerung in Eisenhüttenwerken), G. Bulle. Stahl u. Eisen, vol. 41, no. 29, July 21, 1921, pp. 985–994, 6 figs. Advantages of firing with pulverized coal from technical and economic standpoint.

**Trent Cleaning Process.** Trent Process for Cleaning Powdered Coal, O. P. Hood. Iron Age, vol. 108, no. 6, Aug. 11, 1921, p. 323. Agitation method of producing an amalgam and eliminating ash from low-grade fuels.

**PUMPING STATIONS**

**Cleveland.** The Division Pumping Station at Cleveland, Ohio, J. N. H. Christman. Jl. Am. Water Wks. Assn., vol. 8, no. 4, July 1921, pp. 433–441. Particulars of construction and equipment.

**PUMPS**

**Boiler-Feed.** Water and Air Pumps for Small Deliveries with Eccentric Drive (Wasser-und Luftpumpe für geringe Fördermengen mit Antrieb durch Exzenter), H. Mitusch. Fördertechnik u. Frachtverkehr, vol. 14, no. 3, Feb. 4, 1921, pp. 33–34, 5 figs. Description and illustrations demonstrating arrangement of pumps with eccentric drive for use where crank drive is inexpedient.

**PUMPS, CENTRIFUGAL**

**Piston vs.** Centrifugal Versus Piston Pumps (Kreiselpumpe oder Kolbenpumpe?) Alfred Schacht. Fördertechnik u. Frachtverkehr, vol. 14, no. 7, Apr. 1, 1921, pp. 79–80, 1 fig. Cost of installation of centrifugal pump is said to be about half that of steam piston pump, and foundations can be easily and cheaply constructed. Condensation water of turbine is free of oil and can be directly reused for boiler feed.

**Reciprocating Pumping Engines vs.** Comparison between Reciprocating Pumping Engines and Turbo-driven Centrifugal Pumps, Hugh Lupton. Engineering, vol. 112, no. 2897, July 8, 1921, pp. 74–76. Includes tables showing consumptions and costs of triple-expansion pumping engines and steam turbine-driven centrifugal pumps. Paper read before Instn. Civ. Engrs.

**PUNCHES**

**Design.** The Design and Construction of Press Tools—X. Eng. Production, vol. 3, no. 42, July 21, 1921, pp. 56–58, 6 figs. Considers various kinds of punches and dies. (Concluded.)

**PYROMETERS**

**Equipment for.** Some Essentials of Modern Pyrometer Equipment, H. G. Hall. Can. Machy., vol. 26, no. 3, July 21, 1921, pp. 38–40, 4 figs. Discusses simplicity of design, cost of thermocouple upkeep, etc.

# R

**RADIOMETALLOGRAPHY**

**Spectral Analysis of Metals.** Radiometallography (La Radiométallographie), E. Dieudonné. Revue Universelle des Mines, vol. 9, no. 6, June 15, 1921, pp. 557–566, 8 figs. Concludes that by it the spectral analysis of metals has been made possible.

**RAILS**

**Damage Due to Deceleration.** Damage to Tyres and Rails Caused by Brakes or Slipping Wheels, Christer P. Sandberg. Engineering, vol. 112, no. 2897, July 8, 1921, pp. 82–84, 8 figs. Two examples of rail failure are given which are said to be typical of many others for which no adequate explanation has been found. Paper read before Instn. Civ. Engrs.

**Failures.** Split-Head Rail Failure Shows Rupture, James E. Howard. Iron Age, vol. 108, no. 7, Aug. 18, 1921, pp. 393–395, 7 figs. Differs from a piped rail and is often more easily discovered by outcropping at side. (Abstract.) Report of Interstate Commerce Commission.

**Fissures.** A New Theory of Fissure Formation (Eine neue Theorie der Riffelbildung), A. Wichert. Verkehrstechnik, vol. 38, nos. 9 and 11, Mar. 25 and Apr. 15, 1921, pp. 109–113 and 140–143, 7 figs. New theory of fissuring is developed and means of preventing it described. Details of apparatus for investigation of formation of fissure designed by author and built by Greater Berlin Street Railway, tests with which are to be carried out by Brown, Boveri & Cie., Mannheim.

**Specifications.** A New Rail Specification Proposed, Robert W. Hunt. Iron Age, vol. 108, no. 5, Aug. 4, 1921, pp. 262–263. Provides for rolling tie plates from top of each ingot. Treatment in soaking pits. Lenient as to cold straightening.

New Specification for Rails, Robert W. Hunt. Ry. Age, vol. 71, no. 6, August 6, 1921, pp. 255–256. New specifications to compose difference between existing rail-makers and users.

**Welding.** Welding of Rails by Aluminothermic Processes, (La soudure des rails de tramways par les procédés aluminothermiques), M. Guiffart. L'Industrie des Tramways, vol. 15, no. 171–172, March-April 1921, pp. 41–47, 9 figs. Practice of French General Company of Tramways.

**RAILWAY ELECTRIFICATION**

**Brazil.** Electrification of the Paulista Railway of Brazil, W. D. Bearce. Ry. Age, vol. 71, no. 2, July 9, 1921, pp. 80–83, 5 figs. Fuel scarcity forces the adoption of electric motive power on Brazilian wide-gage line.

**Switzerland.** The St. Gothard Electrification. Elec. Ry. & Tramway Jl., vol. 45, no. 1086, July 8, 1921, pp. 17–20, 6 figs. Has adopted single-phase system, 15 periods, at 7,500–15,000 volts on the contact line. Reasons for this choice are discussed.

**RAILWAY OPERATION**

**Demountable Car Bodies.** Speeding Up Terminal Operations. Ry. Gaz., vol. 35, no. 5, July 22, 1921, pp. 218, 8 figs. Describes the use of demountable bodies in conjunction with motor chassis to speed up the handling of traffic.

**Heavy-Tonnage.** Heavy Tonnage Train Handling Demonstrations on Virginian. R. R. Herald, vol. 25, no. 8, July 1921, pp. 23–27, 4 figs. Account of series of heavy-tonnage train-handling demonstrations conducted on Virginian R. R. under auspices of Westinghouse Air Brake Co., which successfully illustrated feasibility of handling trains approximating 16,000 tons gross behind locomotive, even when undertaking involves long descending mountain grades.

**Locomotive Fuel-Oil Stations.** Design and Operation of Locomotive Fuel Oil Stations. Eng. News-Rec., vol. 87, no. 5, Aug. 4, 1921, pp. 183–187, 9 figs. Tank cars discharge into track troughs; storage and service tanks; gravity of pumped supply to engines; oil columns; fire protection.

**Train Control.** Problems of Automatic Train Control. Ry. Gaz., vol. 35, no. 3, July 15, 1921, pp. 124–125. Discusses questions in connection with the prevention of accidents.

The Train Control System of the Midland Railway. Ry. Gaz., vol. 35, no. 2, July 8, 1921, pp. 45–97, 72 figs. partly on supp. plates. Comprehensive review of successful scheme of traffic in which all train-operating arrangements are centralized. Outstanding feature of scheme is said to be its simplicity. Includes figures indicating running efficiency secured by means of control system.

**RAILWAY SHOPS**

**Power and Light for.** Electric Power and Light for Railroad Shops, J. E. Gardner. Ry. Mech. Engr., vol. 95, no. 8, August 1921, pp. 515–518, 1 fig. Trend of development and standards adopted in the power and lighting field.

**RAILWAY SIGNALING.**

**Alternating-Current.** Principles of Alternating Current Signaling, J. S. Holliday. Ry. Signal Engr., vol. 14, no. 7, July 1921, pp. 267–269, 3 figs. Vector combinations and solutions of resistances of impedances. (Continuation of serial.)

Maintenance of A. C. Signal Apparatus, L. F. Vieillard. Ry. Signal Engr., vol. 14, no. 8, August 1921, pp. 229–302, 3 figs. Discusses relays, impedance bonds, resistances and reactances, transformers, etc. (To be continued.)

**Farm-Lighting Unit.** Farm Lighting Units for Signal Operation, F. H. Bagley. Ry. Signal Engr. vol. 14, no. 7, July 1921, pp. 261–263. Proposed system for charging storage batteries at central locations in territory where alternating current is not available.

**Floating Battery.** A. C. Floating Battery for Railway Signaling. Ry. Signal Engr., vol. 14, no. 8, August 1921, pp. 303–306, 6 figs. Comparison of this new system with straight a.c. and d.c. signaling and points to be considered in estimates.

**New Signals and Interlockers.** New Signals and Interlockers on the P. & R., B. V. Strickland. Ry. Signal Engr., vol. 14, no. 7, July 1921, pp. 256–261, 10 figs. Details of extensive improvements and additions to signaling system on New York branch of Phila. & Reading road. Notes on pole line construction, power supply, signal lighting, automatic block signaling, etc.

**Position-Light Signals.** The Development of Position-Light Signals, A. H. Rudd. Ry. Signal Engr., vol. 14, no. 7, July 1921, pp. 264–266, 1 fig. Latest design of Pennsylvania Railroad is said to reduce cost of operation and maintenance and promote simplicity and safety.

**RAILWAY SWITCHES**

**Low-Voltage Machines.** Switch Operation by Low-Voltage Machines, C. C. Anthony. Ry. Signal Engr., vol. 14, no. 8, August 1921, pp. 313–315, 1 fig. Discusses where these machines are best employed and their advantages.

**RAILWAY TIES**

**Hollow Steel.** Hollow Steel Ties (Die eiserne Hohlschwelle und die Wirtschaftlichkeit der Bahnunterhaltung), A. Birk. Verkehrstechnik, vol. 38, no. 12, Apr. 25, 1921, pp. 154–156, 6 figs. Describes R. Scheibe's hollow steel ties and compares their elastic properties and weights with those of other ties. Results of tests.

**RAILWAY TRACK**

**Ashpits.** Locomotive Ash-Pit and Coaling Station at Communipaw, New Jersey. Engineering, vol. 112, no. 2898, July 15, 1921, pp. 125–127, 8 figs. The two double submerged pits consist of rectangular reinforced-concrete tanks with piling foundations. Coaling station consists of reinforced-concrete structure spanning eight tracks to any of which any of three kinds of coal can be delivered.

**REFRACTORIES**

**Carborundum.** Carborundum Refractories in Heat Treating Furnaces, M. L. Hartman. Trans. Am. Soc. Steel Treating, vol. 1, no. 10, July 1921, pp. 601–603. Points out success resulting from adoption of carborundum refractories in various heat-treating furnaces.

**Hardness when Heated.** Arrangement For Testing the Hardness of Refractory Materials At High Temperatures (Sur un dispositif pour les essais de dureté des matériaux refractaires a haute temperature), Etienne Rengade & Edmond Desvignes. Comptes rendus de l'Académie des Sciences, vol. 173, no. 3, July 18, 1921, pp. 134–137, 1 fig. Description of a new apparatus superseding the Seger cone.

**Rotary Cement Kilns.** Refractories for Rotary Cement Kilns, Raymond M. Howe. Cement, Mill & Quarry, vol. 19, no. 1, July 5, 1921, pp. 35–36. Service in clinker zone is said to tax refractory materials. Effect of high temperature and changes in temperature. Other materials. Paper read before Portland Cement Assn.

**REFRIGERATING MACHINES**

**Ammonia.** Investigations of an Ammonia Refrigerating Machine (Untersuchungen an einer Ammoniak-Kältemaschine), Walther Fischer. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 27, July 2, 1921, pp. 720–723, 7 figs. Deals especially with influence of cooling water jacket on compressor.

**Compression.** The Compression Refrigerating Machine, Gardner T. Voorhees. Ice & Refrigeration, vol. 61, no. 1, July 1921, p. 23. Gage pressure.

**REFRIGERATING PLANTS**

**Propellers for Brine Agitation.** Modern Propelle Design for Brine Agitation and Circulation, E. A Burrows. Ice & Refrigeration, vol. 61, no. 1, July 1921, pp. 18–19, 10 figs.

**RESEARCH**

**University.** The University and Research, Vernon Kellogg. Chem. Age (N. Y.), vol. 29, no. 7, July 1921, pp. 274–276. Notes on work of Nat. Research Council, and conditions of university research. Paper read at University of Minn.

**RIVETED JOINTS**

**Design.** Principles of Riveted Joint Design, William C. Strott. Boiler Maker, vol. 21, no. 7, July 1921, pp. 191–193 and 212, 6 figs. Discusses types of plate and rivet failures, joint efficiency and calculations involved in determining strength of given riveted seam. (To be continued.)

**RIVETING**

**Gas Rivet Heating.** Experience with Gas Rivet Heating in the Pacific Coast, Letson Balliet. Eng. News-Rec., vol. 87, no. 1, July 7, 1921, pp. 21–22. Shipyard results show better rivets and saving of time and cost. Possibilities for structural work.

**ROLLING MILLS**

**Chilled Rolls.** Chilled Rolls for Rolling Mills (Cylindres de Laminoirs en Fonte trempée), Christian Kluytmans. La Fonderie Moderne, no. 4, April 1921, pp. 81–83. Discusses composition, silicon and other content, and tempering.

**Modern Practice.** Principles of Modern Rolling Practice, E. Cotel. Iron Age, vol. 108, no. 7, Aug. 18, 1921, pp. 396–399, 6 figs. Discussion of great power required for finishing passes. Phenomenon of speed gain (bar acceleration) in rolling. Translated from Montanistische Rundschau.

**Roll Design.** The Logic of Roll Design, W. H. Melaney, Part IV. Blast Furnace & Steel Plant, vol. 9, no. 8, August 1921, pp. 477–478, 1 fig. Discusses maximum draft of each pass and minimum diameter of roll.

**Roll Making.** How Steel Mill Rolls Are Made—I, H. E. Diller. Foundry, vol. 49, no. 15, August 1, 1921, pp. 595–601, 10 figs. Description and illustration of process.

**Scullin Steel Co.** Steel Rolling Mills of the Scullin Steel Company at St. Louis, Mo. (Les Laminoirs de l'Aciérie de la Scullin Steel Company à Saint-Louis, Missouri, E.-U.). Le Génie Civil, vol. 79, no. 1, July 2, 1921, pp. 1–5, 7 figs. Detailed description of plant and equipment.

**ROOF TRUSSES**

**Design.** Basic Principles for the Design of Arched Roof Trusses without Tie Rods (Entwurfsgrundlagen für zweistielige Bogenhallenbinder ohne Zugband), Otto Fröhlich. Beton u. Eisen, vol. 20, no. 2–3, Feb. 4, 1921, pp. 34–38, 7 figs. Tables and calculations supplementing those for arched roof trusses with tie rod developed by author and published in same journal (nos. 9–10, 1919).

**ROPE DRIVE**

**Grünig Pulley.** The Grünig Single-Groove Rope Driving Pulleys (Die einrillige Seiltreibscheibe nach dem Patente des Ing. Albert Grünig), Gustav Ryba. Montanistische Rundschau, vol. 13, nos. 11, 12 and 13, June 1, 16 and July 1, 1921, pp. 203–206, 225–228 and 247–249, 10 figs. Points out disadvantages of multiple driving pulleys and describes principles and construction of Grünig's patented single-groove pulley.

# S

**SCIENTIFIC MANAGEMENT**

See INDUSTRIAL MANAGEMENT.

**SEAPLANES**

**Types.** Hydroplanes (Les Appareils Marins d'Aviation), Guitton. L'Aéronautique, vol. 3, no. 25, June 1921, pp. 229–231, 1 fig. Describes the Bréguet Caudron, Savoia and Farman types.

**SEMI-DIESEL ENGINES**

**Small Central Stations.** Semi-Diesel Engines in Small Central Stations, W. S. Barnes. Power, vol. 54, no. 3, July 19, 1921, pp. 96–97, 2 figs. Describes 250-hp. engine direct-connected to an alternator. Typical log sheet covering 24-hr. period of operation shows remarkably high fuel economy at varying loads as well as over-all economy.

**SHAFTS**

**Critical Speeds.** On the Critical Velocity of Shafts (Sulle Velocita Critiche Degli Alberi), Pietro E. Brunelli. L'Industria, vol. 35, no. 12, June 30, 1921, pp. 269–272, 4 figs. Mathematical calculations for various given conditions.

**Large, Straightening.** Straightening a Large Shaft by the Heat Process, Frank G. Frost. Proc. La. Eng. Soc., vol. 7, no. 2, Apr. 1921, pp. 85–91, 2 figs. Details of straightening a shaft of a vertical Curtis turbo-generator in a New Orleans generating station.

**SHEARS**

**Heavy.** Heavy Shears Without Flywheel (Schwere Blechschere ohne Schwungrad). Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 28, July 9, 1921, pp. 744–746, 6 figs. Details of shears built by Thyssen & Co. Corp. Machine Works, Mülheim, cutting plates up to 45 mm. thick and 3000 mm. wide out of steel with tensile strength of 700 kg. per sq. mm. Advantages over shears with flywheel.

**SLAG**

**Blast-Furnace.** Color Classification of Blast Furnace Slags, Wallace G. Imhoff. Blast Furnace and Steel Plant, vol. 9, no. 7, July 1921, pp. 433–434. Scientific investigation on nature of slag itself; color classification of slags of value to blast-furnace men. (To be continued.)

**SPRINGS**

**Flat.** Design of Flat Springs, Joseph Kaye Wood. Am. Mach., vol. 55, no. 2, July 14, 1921, pp. 46–49, 5 figs. Importance of "spring criterion." Derivation of formulas. Triangular-shaped flat springs. Work and resilience in cantilever springs.

**Helical.** A Chart for the Design of Helical Wire Springs, R. Brooks. Engineering, vol. 112, no. 2900, July 29, 1921, pp. 173–175, 9 figs. Expressions are developed on which diagrams are built up, and from these the complete proportions of a spring to meet any required specification can be determined with practically no calculation.

**STANDARDIZATION**

**Holland.** Standardization in Holland (Normung in Holland), Ernst Hijmans. Betrieb, vol. 3, no. 19, June 25, 1921, pp. 582–595, 12 figs. Discussion of fundamental principles underlying standardization in Holland. Examples of standard sheets.

**German N.D.I. Reports.** Report of the German Industry Committee on Standards (Mitteilungen des Normenausschusses der Deutschen Industrie). Betrieb, vol. 3, no. 19, June 25, 1921, pp. 283–292, 16 figs. Proposals of Board of Directors for studs with journal ends; screw-end pins; set screws with various kinds of points; hexagonal cap screws, etc. Proposed new standards for round-head, flat and oval-head countersunk head machine screws with rolled threads.

Report of the German Industry Committee on Standards (Mitteilungen des Normenausschusses der Deutschen Industrie). Betrieb, vol. 3, no. 17, May 25, 1921, pp. 247–255, 12 figs. Proposal of Board of Directors for drawings; shank and sleeve tapers; chamfering and grooving; 45-deg. Y-branches, offsets and double Y-branches; basement sink-water traps. Proposed standards for drawings for helical, spiral and laminated springs; hoisting chains, both calibrated and uncalibrated.

Report of the German Industry Committee on Standards (Mitteilungen des Normenausschusses der Deutschen Industrie). Betrieb, vol. 3, no. 18, June 10, 1921, pp. 259–266, 7 figs. Proposal of Board of Directors for universal joints and shafts therefor. Proposed new standards for indicator cocks; metal screw inserts for insulated handles; solid insulated handles and knobs.

**STEAM-ELECTRIC PLANTS**

**Fuel Economy.** Cutting Coal Consumption a Third. Elec. Ry. Jl., vol. 58, no. 7, August 13, 1921, pp. 232–237, 10 figs. Describes improvements made in the power plant of Wilmington and Philadelphia Traction Co.

**STEAM POWER PLANTS**

**Candy Factory.** Power for Candy Making. Power Plant Eng., vol. 25, no. 15, August 1, 1921, pp. 743–747, 6 figs. Robt. A. Johnston Co.'s plant in Milwaukee. Installations of power-generating, refrigerating and air-conditioning equipment.

**Modern Type.** New Plant of the Continental Motors Corporation. Power Plant Eng., vol. 25, no. 16, August 15, 1921, pp. 789–796, 13 figs. Discusses coal- and ash-handling equipment, the boiler room, turbine room, auxiliaries and instruments.

**STEAM TRAPS**

**Sugar Factories.** Meditations on Trapology—III, J. O. Frazier. Int. Sugar Jl., vol. 23, no. 271, July 1921, pp. 382–385, 1 fig. The role of the steam trap in the sugar factory. (To be continued.)

**STEAM TURBINES**

**Critical Speeds.** The Calculation of Critical Speeds. Engineering, vol. 112, no. 2896, July 1, 1921, pp. 1–2, 3 figs. Discusses Bauman's rule for critical speed of turbine rotors.

**High-Capacity.** Steam Turbines for Limit Performances (Die Dampfturbinen für Grenzleistungen), A. Loschge. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 28, July 9, 1921, pp. 739–744, 10 figs. Development of the limit-performance turbine; influence of low-pressure blading on limit output. Calculation of strength of blades; limits of maximum capacity. Different construction types. Significance of super-critical velocity of steam.

**Modern Types.** Recent Advances in Steam Turbine Design, Gerald Stoney. Elecn., vol. 86, no. 2249, June 24, 1921, pp. 774–780, 14 figs. Details of various modern types. Notes on high-vacuum difficulties; disadvantages of higher blade speeds; effects of high steam temperature; bending troubles; blading material; advantages of Monel metal; etc.

**STEEL**

**Artificial Seasoning.** Artificial Seasoning of Steels, H. J. French. Chem. & Metallurgical Eng., vol. 25, no. 4, July 27, 1921, pp. 155–158. Review of available data on length changes and spontaneous generation of heat in hardened steels, together with results of preliminary experiments on artificial seasoning by different methods of several types of steels used for making limit gages.

**Cold-Drawn.** Production and Uses of Cold-Drawn-Steel, C. E. Bregenzer. Iron Age, vol. 108, no. 3, July 21, 1921, pp. 135–136, 1 fig. Annual output estimated at 900,000 tons. Automobile field largest consumer.

**Motor-Valve.** Steels for Internal-Combustion Motor Valves—II, G. Gabriel. Automotive Mfr., vol. 43, no. 3, June 1921, pp. 16–17 and 26–27. Details of various steels tested and results obtained. Enumeration of desirable and undesirable properties. Kinds of steel recommended.

**Low-Carbon, Forging Tests with.** Forging Tests with Low-Carbon Steel (Schmiedeversuche an Flusseisen), Paul Junkers. Stahl u. Eisen, vol. 41, no. 20, May 19, 1921, pp. 677–687, 23 figs. Results of tests with two grades of low-carbon steel containing 0.13 and 0.50 per cent carbon respectively, carried out for purpose of determining influence of reduction of cross-section and of forging temperature on mechanical properties and structure; also resistance of iron to deformations at different temperatures.

**Nitrogen in.** An Occurrence of Nitrogen in Steel, A. A. Blue. Iron Age, vol. 108, no. 1, July 7, 1921, pp. 1–5, 20 figs. Effect of gases on a light forging left accidentally in a furnace flue. Critical analysis of resulting structures.

**Overstrain.** Effect of Overstrain on the Elastic Properties of Steel. Iron & Coal Trades Rev., vol. 103, no. 2785, July 15, 1921, pp. 73. (From R. D. Report No. 45, Research Dept. at Woolwich.) Gives a summary of tests carried out with overstrained steels.

**Pickling, Effect of.** Embrittling Effect of Pickling Upon Carbon Steel, C. J. Morrison. Iron Age, vol. 108, no. 6, Aug. 11, 1921, pp. 334–335, 3 figs. Study of grain sizes shows that pickling increases width of junction lines between grains.

**Properties and Mibrostructure.** Properties and Miscrostructure of Heat Treated Nonmagnetic, Flame, Acids add Rust Resisting Steel, Charles M. Johnson. Trans. Am. Soc. Steel Treating vol. 1, no. 10, July 1921, pp. 554–575, 47 figs. Describes certain unusual properties of steel produced as result of author's study of steels. Photomicrographs.

**Properties at High Temperatures.** Investigation of the Mechanical Properties of Steels at High Temperatures (Recherches expérimentales sur les propriétés mécaniques des aciers aux températures elevées), Eugene Dupuy. Révue de Métallurgie, vol. 18, no. 6, June 1921, pp. 331–365, 39 figs. Detailed study of fracture and elongation, giving experimental results.

**Specifications.** Proposed Revised Specifications for Steel Products. Blast Furnace & Steel Plant, vol. 9, no. 8, August 1921, pp. 498–505. Abstract of recent report of committee of American Society for Testing Materials covering steel rails, steel pipe, boiler and superheater tubes.

**Tool.** The Oxidation of Carbon Tool Steel on Heating in Air, Howard Scott. Chem. & Metallurgical Eng., vol. 25, no. 2, July 13, 1921, pp. 72–74, 9 figs. Results of experiments show that below 850 deg. cent. and for period up to five hours there is no appreciable decarbonization—that is, scaling at least keeps space with decarbonization.

[See also MOLYBDENUM STEELS; NICKEL STEEL; STEEL, HIGH-SPEED; STRUCTURAL STEEL.]

**STEEL CASTINGS**

**Centrifugally Cast.** Tests of Centrifugally Cast Steel, George K. Burgess. Techn. Papers Bur. Stand., no. 192, 22 pp., 9 figs. Six castings were examined as to their physical and chemical properties, showing the possibility of substituting heat treatment for forging in this type of casting.

**Green-Sand.** Steel Castings Made in Green Sand, W. H. Roesner. Foundry, vol. 49, no. 14, July 15, 1921, pp. 552–554, 5 figs. When proper precautions are observed steel castings poured in this medium are said to present as pleasing an appearance as any gray iron or malleable castings.

**STEEL, HEAT TREATMENT OF**

**Factors Governing.** Factors Governing the Production of Heated Products, J. A. Brown. Trans. Am. Soc. Steel Treating, vol. 1, no. 10, July 1921, pp. 575–587. Summary of factors to be considered.

**STEEL, HIGH-SPEED**

**Manufacture.** The Manufacture of High Speed Steel, Felix Kremp. Official Proc. Central Ry. Club, vol. 29, no. 3, May 1921, pp. 1042–1046 and (discussion) pp. 1046–1051. Details of manufacture.

**STEEL WORKS**

**England.** The New Darnall Works of Messrs. Davy Brothers, Limited. Iron & Coal Trades Rev., vol. 102, no. 2782, June 24, 1921, pp. 841–843, 5 figs. Details of new works for manufacture of steelworks plant and boilers, the Davy patent high-speed forging press, modern rolling-mill plant, and accessories.

**Power Plant for.** Modern Steel Works Power Plant, W. N. Flannigan, Part III. Blast Furnace & Steel Plant, vol. 9, no. 8, August 1921, pp. 510–514. Considers the questions of efficiency and possibilities of saving.

**STRUCTURAL STEEL**

**Plant.** Design of Structural Steel Plant of 5000-Ton Capacity, W. D. Coulter. Can. Engr., vol. 41, nos. 2 and 3, July 14 and 21, 1921, pp. 7 and 11 and 9–10, 5 figs. Layout of plant and buildings; types of buildings and equipment.

**SUPERHEATERS**

**Marine and Locomotive.** Superheaters and Fuel Economy—XII. Machy. Market, no. 1078, July 1, 1921, pp. 21–22, 3 figs. Marine and locomotive superheaters.

**Performance.** Superheaters and Superheat, A. D. Pratt. Mech. Wld., vol. 70, no. 1803, July 22, 1921, pp. 61–63. Discusses safety-valve equipment, superheater performance and variable combustion conditions.

**SWAGING MACHINES**

**Band-Saw.** Swaging and Side-Dressing Machine for Band Saws. Engineering, vol. 112, no. 2900, July 29, 1921, pp. 186 and 188, 9 figs. Machine constructed by A. Ransome & Co., Ltd., Newark-on-Trent, England, can deal with saws from 3½ in. to 8 in. wide and with teeth from 1¼ in. to 2½ in. pitch. It is entirely automatic in operation and works at rate of 20 teeth a minute.

# T

**TAR OILS**

**Low-Temperature.** Uses for Low-Temperature Tar Oils, F. P. Coffin. Gas Age-Rec., vol. 48, no. 3, August 6, 1921, pp. 97–100, 5 figs. Considers creosote and light motor fuel oils.

**TEMPERATURE MEASUREMENT**

**Instruments for.** The Measurement of Temperature—XII, P. Field Foster. Mech. World, vol. 70, no. 1801, July 8, 1921, pp. 32–33, 6 figs. Details of Carpenter-Stansfield deflection potentiometer; and thermocouple indicator made by Foster Instrument Co. Describes several industrial applications of thermocouple pyrometers and methods of mounting. (Continuation of serial.)

**TESTING MACHINES**

**Bar.** Testing Machine Helps, R. W. Allard. Iron

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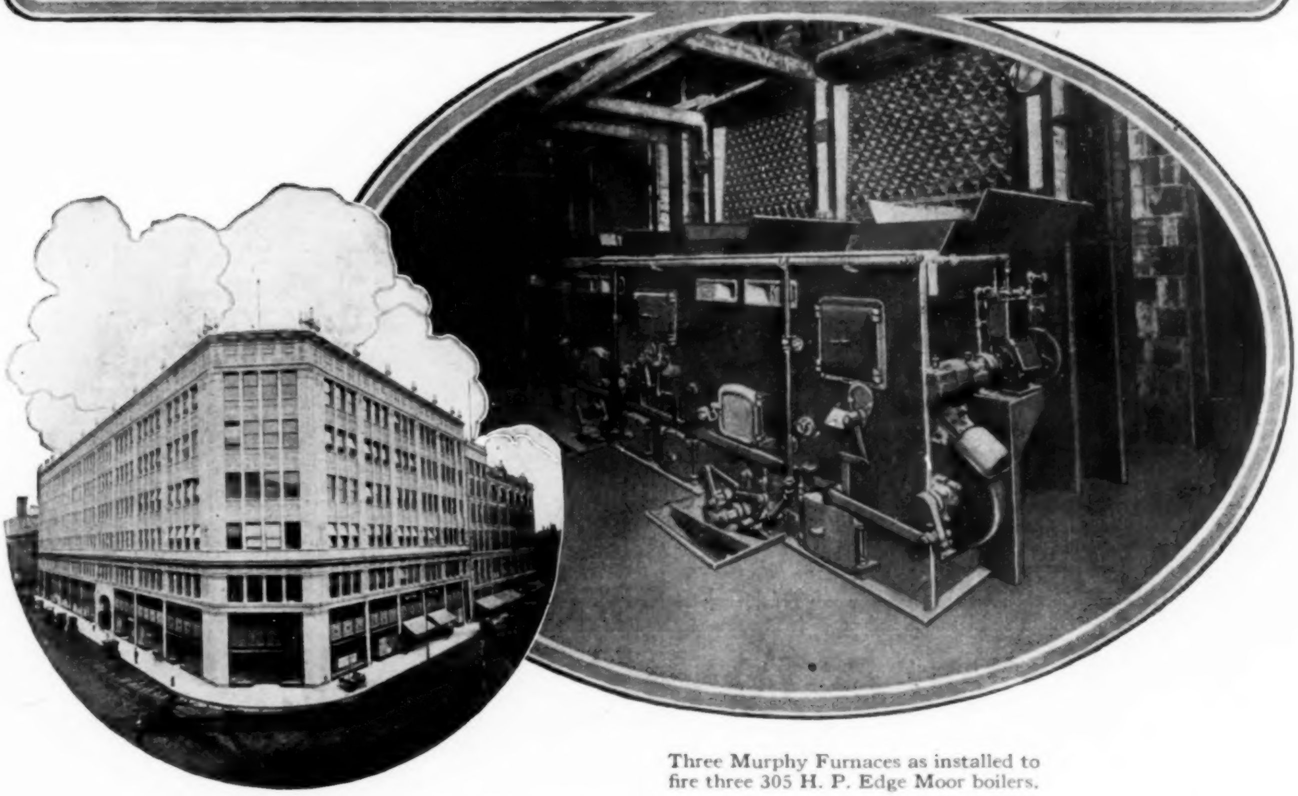

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**ENGINEERING INDEX (Continued)**

Age, vol. 108, no. 2, July 14, 1921, p. 87, 1 fig. Compiling table to translate pounds on test bar into pounds per square inch.

**Brinell Hardness.** The Brinell Test. Machy. (Lond.), vol. 18, no. 459, July 14, 1921, pp. 459–461, 3 figs. Describes two new machines, a power-operated hardness and a small ball hardness testing machine.

The Brinell Testing Machine. Some of Its Uses, Alfred Herbert. Can. Machy., vol. 26, no. 1, July 7, 1921, pp. 75 and 76. Points out advantage of its use for very soft steels, case-hardening steels, non-ferrous alloys, etc.

**TEXTILE INDUSTRY**

**Felt-Manufacturing Machinery.** True or Pressed Felt Manufacturing, J. A. Butler. Textile World, vol. 60, no. 3, July 16, 1921, pp. 27–29, 3 figs. Particulars of machines and processes employed.

**Winding and Warping Machinery.** New Winding and Warping Machinery. Textile World, vol. 60, no. 3, July 16, 1921, pp. 33 and 59, 5 figs. Yarn wound into large cheeses; warping speed 500 to 600 yards per minute. Automatic features.

**TEXTILE MILLS**

**Steam Plant.** The Hamilton Plant of the Canadian Cottons Ltd., T. H. Fenner. Power House, vol. 14, no. 14, July 20, 1921, pp. 21–25, 7 figs. Steam plant installed to supply steam for process work and heating.

**Ventilation.** The Ventilation and Humidification of Textile Factories, H. N. Leask. Engineering, vol. 112, no. 2900, July 29, 1921, pp. 202–204, 2 figs. Describes apparatus designed by A. B. Cleworth to meet all requirements of constancy of humidity and ventilation, etc. Presents chart showing average monthly temperatures in weaving shed. Paper read before Rochdale Cotton Spinners' Mutual Improvement Soc.

**THERMIT WELDING**

**Pipe Joints.** Thermit Welded Pipe Joints, R. L. Browne. A.S.R.E. Jl., vol. 7, no. 6, May 1921, pp. 452–457 and (discussion) pp. 457–459, 4 figs. Gives results of tensile and bursting tests, and vibration tests.

**THERMODYNAMICS**

**Definition.** Critical Discussion of the Traditional Definition of Thermodynamics (Kritische Betrachtungen zur traditionellen Darstellung der Thermodynamik), M. Born. Physikalische Zeit., vol. 22, nos. 7, 8 and 9, Apr. 1, 15 and May 1, 1921, pp. 218–224, 249–254 and 282–286, 3 figs. Deals with work by C. Carathéodory entitled Investigations of the Fundamental Principles of Thermodynamics, published in Math. Annalen (vol. 61, p. 355, 1909), of which, author claims, too little is known among physicists. Points out importance of work for explaining fundamental conceptions and as a basis for instruction.

**TIDAL POWER**

**France.** Project For Utilizing the Tides in the Bay of Rothèneuf [Project d'Utilisation des Marées dans la Baie de Rotheneuf (Ille-et-Vilaine) ], Ch. Dantin. Le Génie Civil, vol. 79, no. 5, July 30, 1921, pp. 102–106, 9 figs. Discusses tide conditions and proposed turbo-alternator equipment, cost of power, etc.

**Utilization.** Utilizing the Power of the Tides (Utilisation de l'Énergie des Marées), M. Boisnier. Annales des Ponts et Chaussées, vol. 62, 11th Series, May-June 1921—III, pp. 297–396, 13 figs. Discusses means and methods of accumulating and using the power, also in connection with railway electrification.

Industrial Use of the Power of Tides (L'Utilisation Industrielle de la Force des Marées), Henri Fischer. Bulletin de la Société Industrielle de Mulhouse, vol. 87, no. 3, Mar. 1921, pp. 169–181, 3 figs. Describes the Parisot system.

**TIMBER**

**Waste Elimination.** Industrial Timber Research Abroad and In South Africa, Nils B. Eckbo. So. African Jl. Ind., vol. 4, no. 6, July 1921, pp. 534–539, 6 figs. Concentrates on elimination of wastes and improved utilization of forest products.

**TIME STUDY**

**Watch for.** Time Study Watch That Records Number of Operations Performed in One Hour. Coal Age, vol. 20, no. 2, July 14, 1921, p. 52, 1 fig. Describes new duration time-study watch for timing, analysis and observation of from one to ten operations up to including five minutes of duration.

**TIRES, RUBBER**

**Durability.** Determining Factors for the Life of a Pneumatic Tire, William G. Nelson. Chem. & Metallurgical Eng., vol. 25, no. 4, July 27, 1921, pp. 153–154. Discusses five factors, namely, rubber and compounding materials, fabric, construction, vulcanization and usage. Causes for premature failures of tires.

**Fabric for.** A Brief Analysis of Tire Fabric Manufacture, H. R. Whitehead. India Rubber World, vol. 64, no. 5, August 1, 1921, pp. 814–816, 10 figs. Discusses picking, carding, combing, drawing, slubbing, warping and twisting, weaving.

**Pneumatic.** Dynamic Balance and Construction of the Pneumatic Tire, William Roberts. India Rubber World, vol. 64, no. 5, August 1, 1921, pp. 811–813, 9 figs. Considers variables in tire construction, proper bead location, assembling threads and gives a formula for figuring weight of cured and uncured thread.

The Determining Factors for the Life of a Pneumatic Tire, William G. Nelson. India Rubber World, vol. 64, no. 5, August 1, 1921, pp. 806–808. Considers the five factors, rubber and compounding materials, fabric, construction, vulcanization and usage.

**TOOLROOMS**

**Puget Sound Navy Yard.** Caring for Tools at Puget Sound Navy Yard. Am. Mach., vol. 55, no. 3, July 21, 1921, pp. 94–96, 7 figs. Central tool-grinding room. Novel system of sliding racks for storing milling cutters. Cleansing and lubricating pneumatic tools.

**TRACTORS**

**Caterpillar.** Tractors in the Oil Fields, Earle W. Gage. Oil Field Eng., vol. 23, no. 7, July 1921, pp. 66, 1 fig. Gives particulars of successful application of caterpillar type of tractor.

**Lubrication.** Tractor Lubrication, J. W. Stack. Part II. Sci. Lubrication, vol. 1, no. 6, June 1921, pp. 9–14, 12 figs. Discusses lubrication as applied to internal-combustion-motor-propelled units. (Concluded.)

**TRAILERS**

**Clay-Products Industry.** Use of Trailer Saves Motive Power, Gilbert I. Stodola. Brick & Clay Rec., vol. 59, no. 1, July 12, 1921, pp. 35–38, 6 figs. Application of trailer and semi-trailer in clay-products industry for distribution of clay ware.

**TRUSSES**

**Stress Determination.** Theory of Structures, Ernest W. Dibley. Commonwealth Engr., vol. 8, no. 11, June 1, 1921, pp. 328–329, 9 figs. Describes a method for determining by inspection the nature of stresses in the members of trusses for dead and uniformly distributed live loads.

**TUBES**

**Seamless.** On the Manufacture of Seamless Tubes—IV, Karl Gruber. Blast Furnace and Steel Plant, vol. 9, no. 7, July 1921, pp. 442–444, 6 figs. Seamless tube rolling in Germany, with special consideration of Mannesman pilgrim-step rolling mill.

# U

**U. S. BUREAU OF STANDARDS**

**War Work.** War Work of the Bureau of Standards, U. S. Dept. of Commerce Bur. of Standards, no. 46, Apr. 1, 1921, 299 pp., 35 figs. Short descriptions of more important work carried on during war which was of direct service to military forces. Deals with aeronautic instruments and power plants; aircraft construction, materials, etc.; chemical investigations; coke-oven investigations; concrete ships; electric batteries; electric tractors and trucks; precision gages; illuminating engineering; invisible signaling; magnetic investigations; metallurgical investigations; natural-gas investigations; optical glass and instruments; protective coatings; radio communication; radium; rubber; searchlights; sound-ranging apparatus; wheels; X-rays, etc.

# V

**VIBRATION**

**Measurement.** Measurement of Vibration of the 660-ft. Wireless Telegraph Station Tower at Haranomachi, F. Omori. Engineering, vol. 112, no. 2900, July 29, 1921, pp. 196–199, 13 figs. Results of measurement of movement of tower caused by winds carried on during course and after completion of construction on five different occasions.

**VISCOSITY**

**Effect on Orifice Flows.** The Effect of Viscosity on Orifice Flows, W. N. Bond. Physical Soc. Lond. Proc., vol. 33, part 4, June 15, 1921, pp. 225–230, 2 figs. Results of determinations are plotted in manner which combines both purely viscous and purely turbulent flows in one graph. It is shown that effect of slight viscosity is to increase coefficient of discharge.

# W

**WAGES**

**Incentive vs. Production Basis.** Incentive or Production Basis of Wage Payment—I and II, Henry Farquhar. Am. Mach., vol. 55, nos. 5 and 7, Aug. 4 and 18, 1921, pp. 169–172 and 275–277, 1 fig. Aug. 4: Constructive preparation necessary; effect of working conditions on mental attitude; elements of scientific management; determining standard production time. Aug. 18: Reward for standard accomplishment; variations in types of incentive; aristocracy of skilled labor; individual and group reward.

**Wage-Level Formula.** Past and Future Wage Levels, Halbert P. Gillette. Eng. & Contracting, vol. 56, no. 5, August 3, 1921, pp. 97–101, 2 figs. Develops a wage-level formula for which he concludes that during the past 30 years the per capita bank deposits have increased twice as rapidly as per capita money.

**WAR DEVASTATION**

**Metallurgical Works, France.** Destruction of the Works of the Compagnie Métallurgique Franco-Belge at Mortagne (La Destruction des Usines de la Compagnie Métallurgique Franco-Belge de Mortagne), Marchal. Révue de Métallurgie, vol. 18, no. 5, May 1921, pp. 261–263, 4 figs.

Destruction of French Metallurgical Works by the Germans During the War (Les déprédations et destructions commises par les Allemands aux Usines de Givet de la Compagnie francaise des Métaux pendant la guerre de 1914–18), A. Mercier des Rochettes. Révue de Métallurgie, vol. 18, no. 5, May 1921, pp. 247–259, 17 figs.

**WASTE HEAT**

**Utilization.** The Utilization of Waste Heat in Gasworks, George E. Stewart. Engineering, vol. 112, no. 2897, July 8, 1921, pp. 77–78. Notes on carbonization, water gas manufacture, and waste heat boilers. Paper read before Instn. Civ. Engrs.

**WATER**

**Viscosity.** Viscosity of Water at Low Rates of Shear, Albert Griffiths. Physical Soc. Lond. Proc., vol. 33, part 4, June 15, 1921, pp. 231–242, 4 figs. Determination by method in which water is forced along glass capillary tubes of about 1.5 to 2 mm. bore at rates of flow varying from 1 liter in two years to 1 liter in 24 years.

**WATER POWER**

**Canada.** Available Water Power in Canada. Can. Engr., vol. 41, no. 1, July 7, 1921, p. 1. Figures recently compiled by Dominion water-power branch.

**Development.** Water Power Development, W. E. Williams. Beama, vol. 9, no. 1, July 1921, pp. 19–24, 7 figs. Notes on survey of a catchment area; artificial reservoirs; and linking up of hydroelectric stations.

**Germany.** The Development of German Water Powers (Der Ausbau unsrer Wasserkräfte). Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 26, June 25, 1921, pp. 687–697, 3 figs. Notes on developments in Bavaria, Southwest Germany, Harz and Silesia. Water power in France.

**Montana.** Hydro-Electric Possibilities in Montana, E. W. Kramer. Elec. World, vol. 78, no. 3, July 16, 1921, pp. 111–115, 5 figs. Total water power available placed at approximately 1,000,000 hp., of which 225,000 hp. has been developed. Study of four principal watersheds showing possible developments of over 10,000 hp.

**Rhone River.** Utilization of the Water Power of the Rhône (L'aménagement des forces motrices du Rhône), L.-D. Fourcault. L'Electricien, vol. 52, no. 1280, July 15, 1921, pp. 313–311, 1 fig. Details of project recently adopted.

**Undeveloped.** Probable Water-Power Developments. Elec. World, vol. 78, no. 5, July 30, 1921, pp. 219, 6 figs. Tabulation of the undeveloped water powers of over 10,000 hp. by drainage basins.

**Utilization.** Contribution to the Study of the Determination of the Hydraulic System of a Basin in Terms of Its Rainfall. (Contribution à l'étude du ruissellement et à la détermination du régime hydraulique d'un bassin en fonction de sa pluviosité), Aimé Coutagne. Revue Générale De L'Electricité, vol. 9, no. 25, June 18, 1921, pp. 885–893, 5 figs. Technical study. Application of conclusions derived from central region of France. (To be continued.)

The Employment of Water Power in the Development of the Mineral Industry, John Evans. Engineering, vol. 112, no. 2897, July 8, 1921, p. 76. Past developments and future possibilities. Paper read before Instn. Civ. Engrs.

**WATER SOFTENING**

**Cold Lime-Soda Process.** Water Softening by the Cold Lime-Soda Process, George C. Cook. Power, vol. 54, no. 3, July 19, 1921, pp. 92–94. How boiler priming and scale formation may be prevented by simple chemical treatment. How to conduct tests for causticity and alkalinity in feedwater.

**WATER TANKS**

**Elevated.** Auxiliary Equipment for Elevated Water Tanks, Charles L. Hubbard. Power Plant Eng., vol. 25, no. 14, July 15, 1921, pp. 703–706, 8 figs. Methods employed to prevent the freezing of water tanks and riser.

**WELDING**

See AUTOGENOUS WELDING; ELECTRIC WELDING; ELECTRIC WELDING, ARC; FUSION WELDING; OXY-ACETYLENE WELDING; THERMIT WELDING.

**WELFARE WORK**

**Employees' Mutual Benefit Associations.** Mutual Benefit Associations in Industry, Frederick A. Anderson. Power Plant Eng., vol. 25, no. 16, August 15, 1921, pp. 798–802, 3 figs. Outlines the principles on which such an organization should be organized.

**WIND TUNNELS**

**Compressed Air for.** A New Type of Wind Tunnel Max Munk. Aviation, vol. 11, no. 6, August 8, 1921, pp. 162–163. (Abstract from N.A.C.A. Technical Note No. 60.) Discusses the use of compressed air in wind tunnels, its advantages and difficulties.

**WINDING ENGINES**

**Graphical Dynamics.** The Graphical Dynamics of a Winding Engine—I, Charles D. Mottram. Colliery Guardian, vol. 121, no. 3155, June 17, 1921, pp. 1733–1734, 8 figs., and vol. 122, no. 3157, July 1, 1921, p. 30, 3 figs. Apportionment of external losses in a large steam winding engine at Yorkshire Main Colliery, Doncaster. Determination of hp. developed in raising load only; hp. expended in wind resistance.

**Modern.** Modern Winding Engines—IX, M. Corliss. Mech. World, vol. 70, no. 1801, July 8, 1921, pp. 29–30. Brake gears. (Continuation of serial.)